Fishery Data Series No. 03-27

Production of Coho Salmon from the Unuk River, 2001–2002

by

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and

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December 2003

Alaska Department of Fish and Game Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
Inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

all commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
all commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	var

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ABSTRACT

The Unuk River stock of coho salmon *Oncorhynchus kisutch* was assessed in 2001–2002. Baited minnow traps were fished daily on the Unuk River from 31 March through 23 April, 2001. Captured smolt were marked with coded-wire tags and excision of adipose fins. Different codes were used for small (70–82 mm FL) and for large (≥83 mm FL) smolt. Sampled smolt averaged 84 mm FL and 6.4 g in weight. In 2002, port and creel sampling projects recovered 145 of these coded-wire tags which with expansion represent an estimated harvest of 15,584 (SE = 2,033) in U.S. marine waters. Of this harvest, the troll fishery took an estimated 47%, purse seine and drift gillnet fisheries 22%, and recreational fisheries 8%. An estimated 55,409 (SE = 12,084) adults returned to the Unuk River, as determined by a mark-recapture study using radiotelemetry to estimate handling-induced mortality inriver (14%). Estimated run size (i.e., escapement, harvest, and inriver handling-induced loss) in 2002 for this stock is 71,242 (SE = 12,253); marine exploitation rate was an estimated 22% (SE = 4%). Estimated smolt abundance in 2001 was 757,080 (SE = 142,167) after adjustment for size-specific capture rates and size-specific marine survival rates of smolts. Estimated marine survival rate regardless of smolt size was 9.4% (SE = 2.4%) from 2001–2002.

Key words: coho salmon, *Oncorhynchus kisutch*, Unuk River, harvest, troll fishery, seine fishery, drift gillnet fishery, recreational fishery, mark-recapture, radiotelemetry, escapement, run size, exploitation rate, marine survival

INTRODUCTION

The Unuk River (Figure 1) originates in a heavily glaciated area of northern British Columbia and flows for 129 km where it empties into Burroughs Bay 85 km northeast of Ketchikan, Alaska. The lower 39 km of the river are in Alaska (Figure 2). The total coho salmon *Oncorhynchus kisutch* production originating from the Canadian portion of the river has not been estimated directly; however, information gathered during the first three years of study indicates that as much as 25% of the production likely occurs in Canada (Jones et al. 1999, 2001a, 2001b). The primary spawning tributary within Canada is at Boundary Lake (also known as Border Lake), located about 2 km upriver of the border. While this lake itself offers rearing habitat, any movement by juvenile fish out of the lake and downriver will essentially mean the fish have moved into the U.S. portion of the river. In Southeast Alaska some coho salmon systems are surveyed annually for estimates of spawning abundance. Typically, the Eulachon River is the only Unuk River tributary annually surveyed for coho salmon spawning abundance, with peak counts since 1990 ranging from 235 in 1990 to 1,105 in 2002 and averaging 583 fish.

The Unuk River has produced estimated annual runs (harvest and escapement) of 57,811, 55,147, 31,740, and 68,080 adult coho salmon, respectively, in the years 1998 through 2001 (Table 1). Many (47–79%) of these fish are harvested in marine and recreational fisheries throughout Southeast Alaska (Jones et al. 1999, 2001a, 2001b, Weller et al. 2002). Coho salmon returning to the Unuk River must pass through a series of commercial (i.e., troll, purse seine, and drift gillnet) and recreational fisheries as they travel in a southward migration along the northern outside coast of Southeast Alaska before entering the inside waters of southern Southeast Alaska (Figure 3). Some members of this stock are also harvested in the marine fisheries of northern British Columbia, Canada. Perceived changes in stock run strength in streams near Ketchikan has prompted concerns over the status of coho salmon in Southeast Alaska. Since the Unuk River stock has been shown recently to produce relatively large returns of coho salmon, and has early to mid run timing (important for inseason management), it was selected as an ideal site for estimating trends in harvest exploitation, and survival of wild stocks from the inside waters of southern Southeast Alaska.

Harvests from this stock have been estimated through programs based on coded-wire tags (CWTs). Juvenile coho salmon were tagged from 1983 through 1986, and from 1996 to the present. Recapture of these tags indicate that on average the majority of marine harvest occurs in the

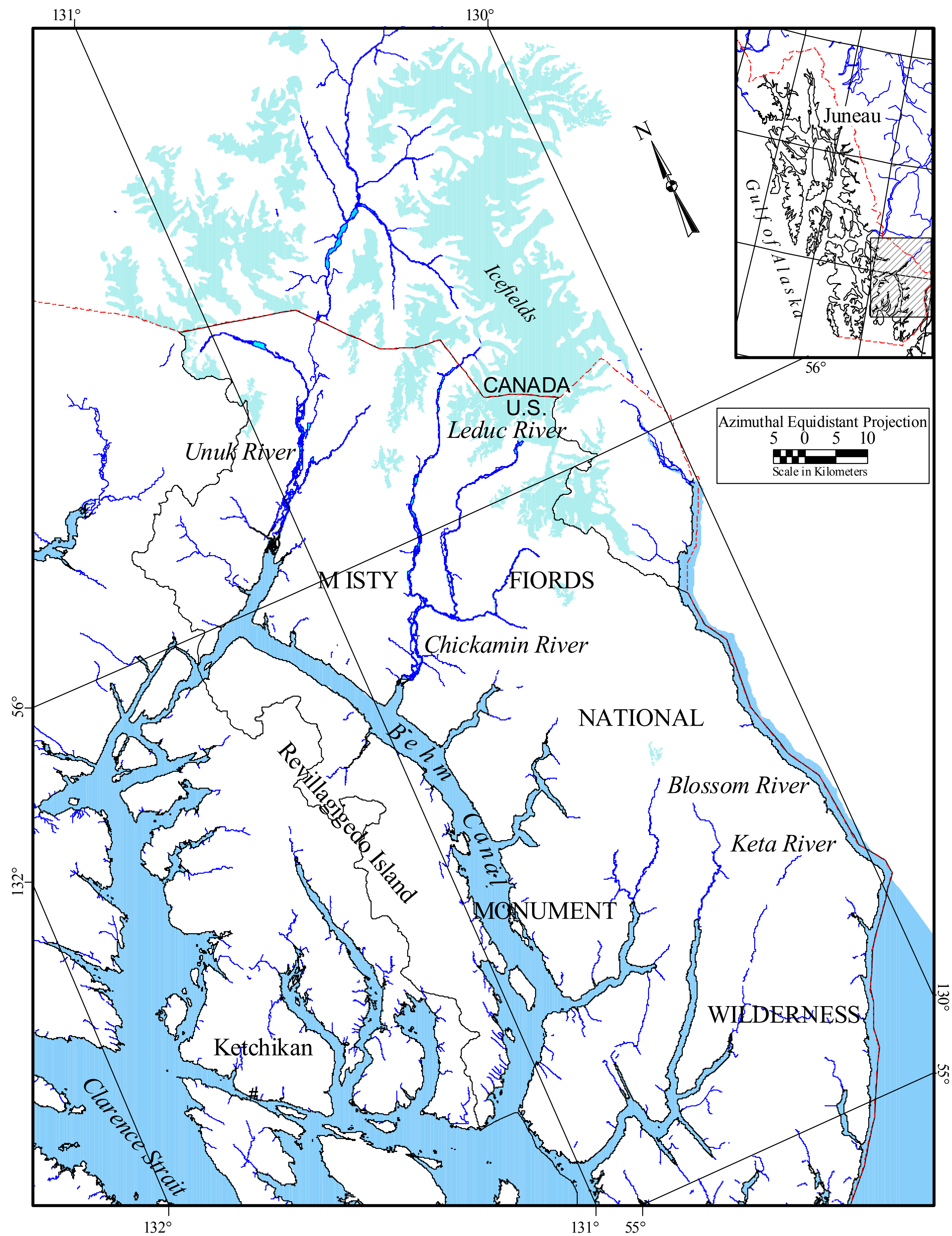

Figure 1.–Behm Canal and surrounding area in Southeast Alaska, with streams supporting major coho salmon stocks noted.

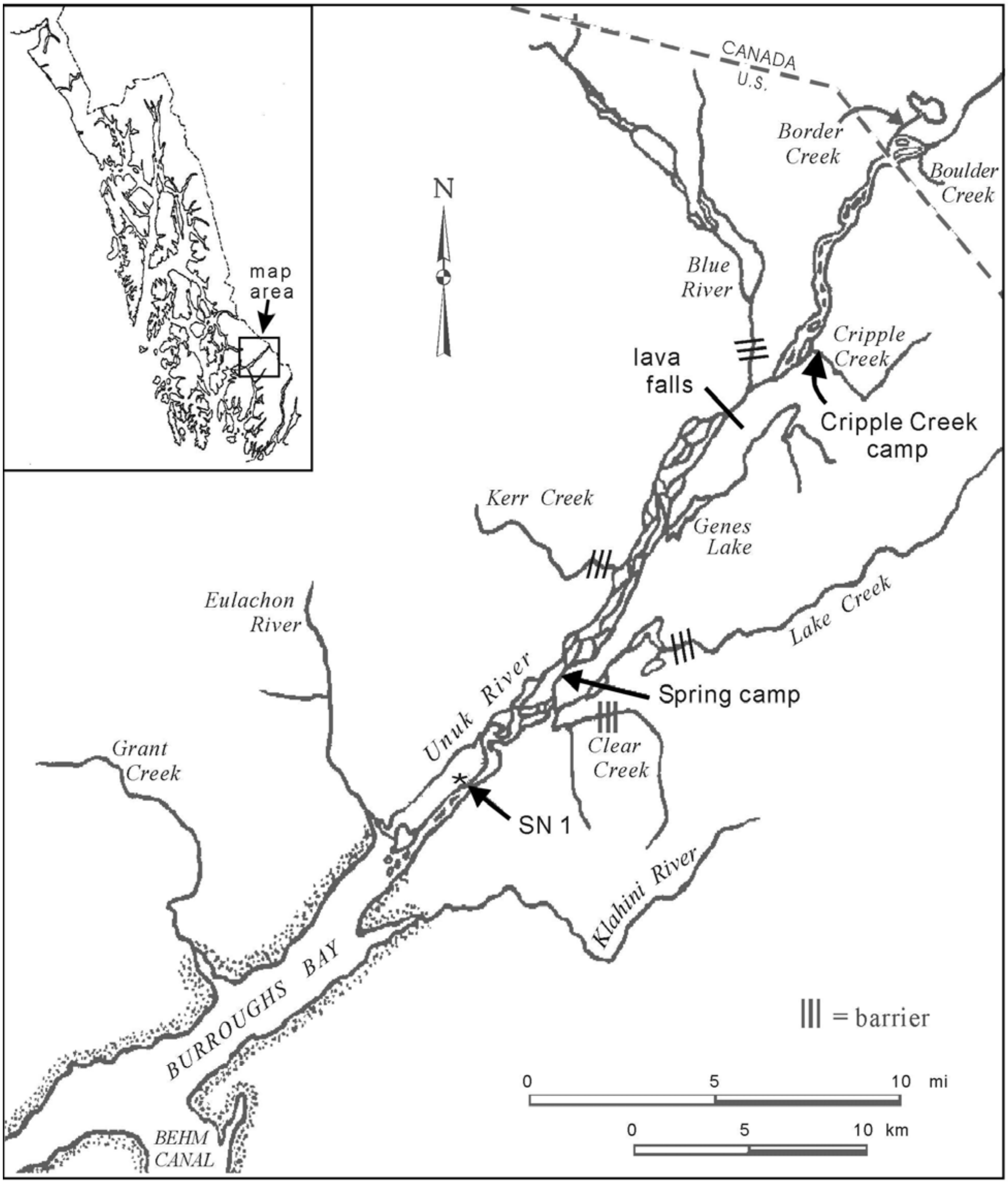

Figure 2.–Unuk River and surrounding area, showing major tributaries, barriers to salmon migration, and locations of ADF&G research sites.

Table 1.–Estimates of run size, harvest, escapement, marine survival rate, exploitation rate, handling mortality of adults, smolt abundance, and smolt size for the Unuk River stock of coho salmon, 1998–2002.

Parameters	1997	1998	1999	2000	2001	2002
Run size		57,811	55,147	31,740	68,080	71,242
SE		8,158	13,201	6,764	9,522	12,253
Harvest		45,388	29,300	14,826	32,633	15,584
SE		7,461	2,950	3,510	6,276	2,033
Escapement		12,422	25,846	16,845	35,022	55,409
SE		3,298	12,867	5,782	7,161	12,084
Relative precision ($\alpha = 0.05$)		52	65	54	40	43
Marine survival rate (%)		7.1	9.8	3.9	11.8	9.4
SE (%)		2.0	2.9	1.5	2.2	2.4
Exploitation rate (%)		79	53	47	48	22
SE (%)		5	12	10	7	4
M-R mortality		181	258	69	425	249
% M-R mortality		24.4	28.2	15.2	26.5	14.3
Smolt abundance	809,677	562,796	819,475	577,343	757,080	
SE	189,345	101,122	257,309	70,720	142,167	
Smolt mean length (mm FL)	84.04	88.87	86.47	83.88	84.24	
SD	9.68	10.28	10.22	10.69	11.13	
Smolt mean weight (gm)	5.76	6.92	6.51	6.12	6.43	
SD	1.81	2.44	2.33	2.67	2.51	

Southeast (47%) and Northwest (35%) quadrants of Southeast Alaska; primarily by troll (55%) gear and to a lesser extent by purse seine (19%), drift gillnet (17%), and recreational (9%) gear (Figure 3) (Jones et al. 1999, 2001a, 2001b, Weller et al. 2002). Fish from the Unuk River composed an estimated 20%, 6%, 0%, and 6% of the Ketchikan marine recreational harvest of coho salmon in 1998, 1999, 2000, and 2001, respectively. A small inriver recreational fishery harvests up to 100 coho salmon annually.

A comprehensive assessment of coho salmon from the Unuk River began in 1996 when tagging (with CWTs) of smolt was resumed. Assessment includes estimation of escapement, harvest, marine survival rates, and exploitation rates of these fish. Between 1998 and 2001 escapement has averaged 22,063 with a range of 12,422 (1998) to 35,022 (2001), harvest averaged 30,423 with a range of 14,826 (2000) to 45,388 (1998), and total run averaged 30,423 with a range of 31,740 in 2000 to 68,080 in 2001 (Table 1). During these years marine survival rates averaged 8.1% with a range of 3.9% (2000) to 11.8% (2001) and exploitation rates averaged 57.8% with a range of 48% (2000 and 2001) to 79% (1998)(Jones et al. 1999, 2001a, 2001b; Weller et al. 2002).

Objectives of the 2001–2002 study were to estimate: (1) abundance and mean length of Unuk River coho salmon smolt in 2001; (2) marine recreational and commercial harvest of adult coho salmon bound for the Unuk River in 2002 and (3) abundance and age, sex, length composition of escapement in 2002. These objectives were accomplished by tagging and sampling smolt in the spring of 2001 and through the operation of an inriver mark-recapture study on adults in 2002.

METHODS

SMOLT CAPTURE, TAGGING, AND SAMPLING

Between 81 and 209 G-40 minnow traps, baited with salmon roe, were fished daily for 24 h from 31 March to 23 April, 2001, between river km 10 and 26 along both banks of the Unuk River. Traps were located along mainstem banks and in some

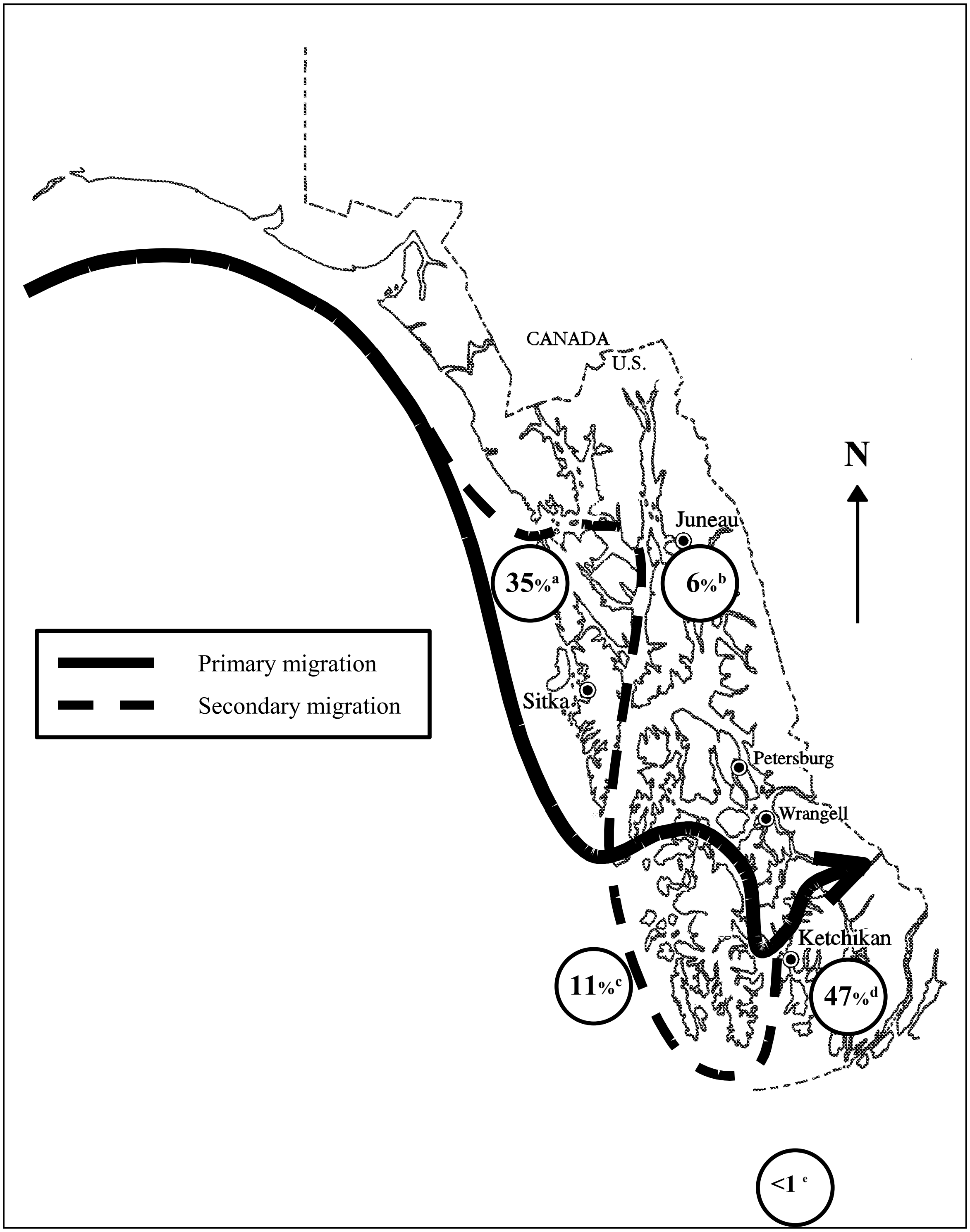

Figure 3.–Migration routes through Southeast Alaska and average percentage of marine harvest (1998–2002) by quadrant for the Unuk River stock of coho salmon. Superscripts denote quadrants: [a]Northwest, [b]Northeast, [c]Southwest, [d]Southeast, and [e]Canadian.

backwater areas, depending on river levels. Minnow traps were checked daily when water levels were stable and more frequently when not. Two teams consisting of two personnel each were used to set and fish traps on a regular basis. Generally, one crew was responsible for traps set upstream of Spring Camp (km 14) and one crew responsible for traps downstream of camp. Early in the season, water levels were low and ice and snow restricted fishing to the mainstem banks. These conditions slowly changed within the first few weeks.

Juvenile fish were removed from minnow traps during each visit, transported to holding pens at camp, and tagged and marked each day. Coho and chinook salmon *O. tshawytscha* smolt were separated from other species of salmon and Dolly Varden *Salvelinus malma* by using a combination of external morphological characteristics. Absence of pigmentation or a clear 'window' in the adipose fin indicates a chinook salmon (Meehan and Vania 1961; McConnell and Snyder 1972), whereas coho salmon have a mottled or speckled adipose fin. In addition, chinook salmon generally appear silvery when viewed from the side, in contrast to coho salmon, which are often darker with a purple hue. Coho salmon tend to have narrower par marks, a greater number of small, darkly pigmented spots when viewed dorsally, and longer anterior rays on their anal fins (Pollard et al. 1997).

All live, smolting coho salmon were tranquilized in a water solution of tricain methane-sulfonate (MS 222) buffered with sodium bicarbonate. To alleviate stress on smolts, the anesthetic solution was kept near ambient river temperature by frequent water changes, and numbers of smolt tranquilized at any one time were kept small to limit their exposure. All smolt ≥70 mm FL not missing adipose fins were tagged following procedures described in Koerner (1977) and their adipose fins were excised. Different codes were used on tags implanted in small smolt (70–82 mm FL) and large smolt (≥83 mm FL) to permit subsequent detection of possible size-specific differences in marine survival rates. All chinook salmon smolt ≥50 mm FL were also tagged, albeit with different codes. All captured smolt of either species absent an adipose fin were passed through a magnetic tag detector, and the presence or absence of a tag recorded.

All tagged fish were held overnight and then released the following morning after being checked for tag retention and mortality. The number of fish tagged, the number that died in the holding pen, and the number of fish that had shed their tags were compiled and recorded on *ADF&G CWT Tagging Summary and Release Information Forms.* These forms were submitted to the Commercial Fisheries Division Tag Lab in Juneau after the field season. Length and weight composition of smolting coho salmon in 2001 was estimated by systematically sampling every 124th smolt captured. Each sampled smolt was measured to the nearest mm FL and weighed to the nearest 0.1 g.

ESTIMATING SMOLT ABUNDANCE

Abundance of smolt in 2001 was to be estimated with a two-event mark-recapture study using Chapman's modification of the Petersen estimate (Chapman 1951). To be consistent, this estimator must meet the following conditions:

- *(a)* regardless of its size, every smolt had an equal probability of being tagged and marked, or every tagged smolt had an equal probability of being captured as an adult (proportional sampling); or
- *(b)* marked fish mixed completely with unmarked fish in the population between events; and
- *(c)* there was no recruitment to the population between sampling events; and
- *(d)* there was no tag-induced mortality; and
- *(e)* fish did not lose their marks in the time between the two events; and
- *(f)* all marked fish were recognized.

Evidence is that conditions $b - f$ were met. Temporal and spatial variation in marked fractions of escapement indicated that marked fish had mixed completely with unmarked fish while at sea. The fidelity of coho salmon to their natal watershed precludes recruitment. No short-term, tag-induced mortality was indicated, nor was there discovered a significant loss of tags in sampled adults. Coastwide experience is that excised adipose fins do not grow back. However, small smolt (70–82 mm FL) were demonstrably marked and survived at different rates than did large smolt (≤ 83 mm FL). For this reason, the estimator was modified to remove the implied bias:

$$\hat{N}_S^* = \frac{(\hat{A}M_1 + M_2 + 1)(C+1)}{\hat{A}R_1 + R_2 + 1} \qquad (1)$$

where N_s was number of smolt emigrating in 2001, M_1 and M_2 were the number of small and large smolt marked in 2001, C was the number of adults sampled during in 2002, R_1 and R_2 were the number of marked small and large smolts recaptured as adults, and A is the adjustment for consistency. Evidence of these differences and the methodology used to estimate smolt abundance are provided in Appendix B1. This appendix also includes a description of simulations used to estimate the variance and potential statistical bias in the adjusted estimate.

ESTIMATING ESCAPEMENT

A two-event mark-recapture study was used to estimate the escapement of adult coho salmon into the Unuk River in 2002. In the first event, fish were captured in the lower river at SN1 between 31 July and 28 September using two set gillnets. Site SN1 is located on the south channel of the lower Unuk River, at approximately river km 3, and is downstream of all known coho salmon spawning tributaries with the exception of the Eulachon River (Figure 4). Both gillnets were 37 m (120 ft) long by 4 m (14 ft) deep. One gillnet used 14-cm (5⅜") stretch mesh and the second gillnet had 11.5-cm (4½") stretch mesh. Similar studies conducted on the Unuk River from 1998 to 2001 indicated that a sufficient number of coho salmon could be captured using set gillnets fished at SN1 (Jones et al. 1999, 2001a, 2001b; Weller et al. 2002). Set gillnets were fished by each crew (2 crews) for 5 hours per day, 6 days a week. One net (a cross net) was attached to the shore and ran directly across a small slough to a fixed buoy placed just downstream of a small island perpendicular to the main flow of the Unuk River (Figure 5). Another net (a lead net) was attached to the same buoy and fished downstream along the eddy line created between the mainstem flow and the side slough. The 11.5- and 14-cm stretch mesh gillnets were alternated daily between cross and lead net positions.

All fish captured, regardless of condition and not including recaptures, were sampled to determine their age, sex, and length (ASL). Length was measured to the nearest 5 mm MEF, and gender was determined from external characteristics. Five scales approximately 2 cm apart were taken from the preferred area on the left side of the fish. The preferred area is two to three rows above the lateral line and between the posterior terminus of the dorsal fin and the anterior margin of the anal fin (Scarnecchia 1979). Scales were mounted on gum cards capable of holding scales from 10 fish as described in ADF&G (1993). The age of each fish was later determined from the pattern of circuli as seen on images of scales impressed into acetate cards (Clutter and Whitesel 1956; Moser 1968) under 70× magnification. Fish missing adipose fins were noted as such and then sacrificed by having their heads removed and sent to the Tag Lab in Juneau for detection and decoding of CWTs.

Each captured fish possessing an adipose fin and not previously sampled was marked in three different ways: a uniquely numbered solid-core spaghetti tag, a clip of the left axillary appendage (LAA), and a left upper operculum punch (LUOP) ¼" in diameter. The two secondary marks enabled detection of primary tag loss. The spaghetti tag (primary mark) consisted of a 5.71-cm (2¼") section of laminated Floy tubing shrunk onto a 38-cm (15") piece of 80-lb-test monofilament fishing line. The monofilament was sewn through the back just behind the dorsal fin and secured by crimping both ends of the monofilament in an aluminum line crimp and excess line was cut off. Each spaghetti tag was printed with a unique number and an ADF&G contact phone number.

Radiotelemetry was used to estimate the proportion of adults marked during the first event that suffered handling mortality or left the Unuk River prior to spawning. Between 17 August and 25 September, transmitters from Advanced Telemetry Systems™ (151 MHz) were inserted through the esophagus into the

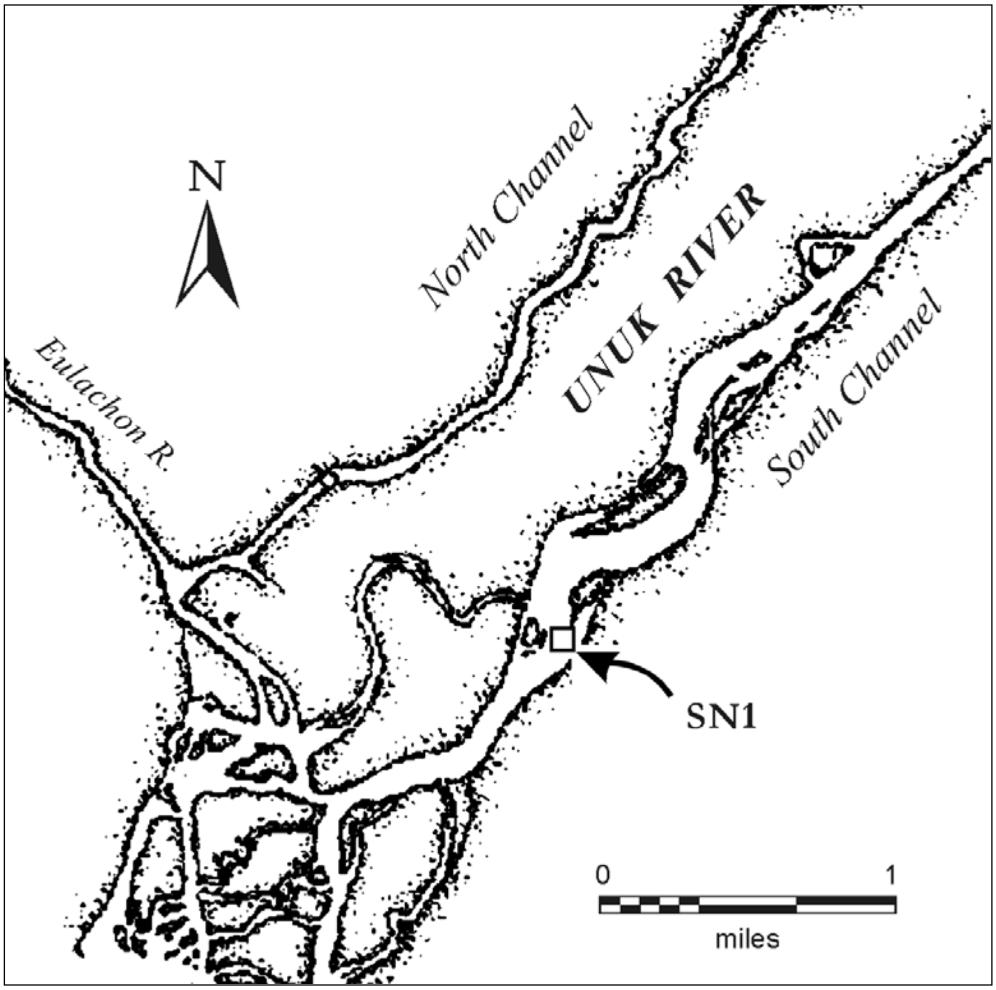

Figure 4.–Location of the set gilnet site (SN1) on the lower Unuk River in 2002.

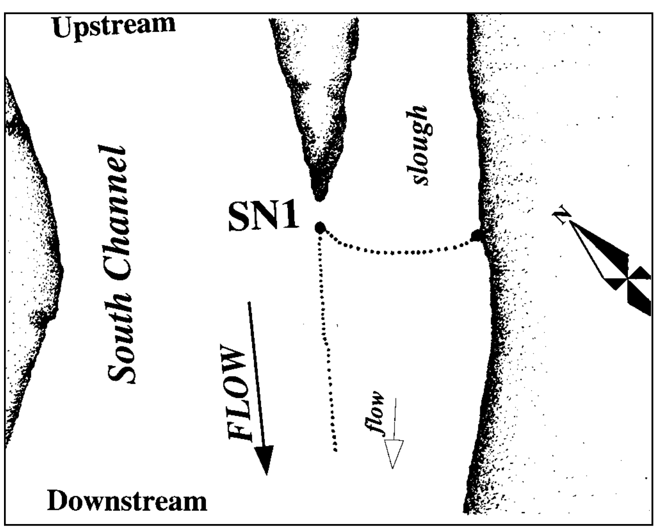

Figure 5.–Detailed drawing of net placement used at the set gillnet site (SN1) on the lower Unuk River in 2002.

stomachs (as per methods described in Eiler 1990) of healthy adult coho salmon. One out of every 32 captured fish was chosen systematically for implantation. Every fish that received a radio transmitter was also tagged, marked, and sampled as described above.

In the second event of the mark-recapture experiment, adult salmon were captured on the spawning grounds in the Eulachon River and Lake, Boundary, Gene's Lake, Kerr, Cripple, and Clear creeks (see Figure 2). Various gear types, such as rod and reel snagging, bait and lures, and pieces of gillnet were used to capture fish. The use of multiple gear types has been shown to reduce bias in estimates of age, sex, and length composition when sampling chinook salmon (Jones et al. 1998; Jones and McPherson 1999, 2000). In addition, set gillnets were fished at two separate upriver locations (km 13 and 16) in 2002; configuration of nets was similar to those used at SN1. All fish captured during the second event were marked with a left lower operculum punch (LLOP) to prevent double sampling in subsequent sampling visits. Sampled fish were closely examined for the presence of an adipose fin, a tag, LUOPs, LLOPs, and LAAs. All fish were sampled to obtain ASL data using the same techniques applied at SN1.

Fixed-wing aircraft and stationary recorders were used to locate surviving test subjects with transmitters. On 6 September, 30 September, and 28 October, a pilot along with an experienced member of the crew surveyed the entire U.S. portion of the Unuk River and into Canada as far as river km 65. In addition to tracking flights, two tracking towers were placed near camp at approximately river km 14; towers were constructed and operated as described in Eiler (1995), except that they did not have satellite uplink capabilities. A reference transmitter was used to check whether or not each tower was operational, and data loggers were checked periodically for the indication of fish movement. Fish were presumed to have spawned if they were tracked upstream of the tagging site (beyond river km 6), or to the Eulachon River, or by a positive reading at one of the radio towers. Fish not located by either method, located below the set gillnet site (SN1; Figure 4, 5), or located outside the system, were considered mortalities.

Escapement of adult coho salmon in 2002 was estimated using and adaptation of Chapman's modification of the Petersen's estimator (Seber 1982):

$$\hat{N}_e = \frac{(\hat{n}_1+1)(n_2+1)}{(m_2+1)} - 1 \qquad (2)$$

where $\hat{N}_e$ is the number of adult coho salmon immigrating into the Unuk River in 2001, $\hat{n}_1$ is the estimated number of fish marked during the first event that continued up the river, n_2 is the number inspected for marks during the second event, and m_2 is the subset of n_2 that possessed marks applied during the first event. The estimate $\hat{n}_1$ was calculated as:

$$\hat{n}_1 = n_1'(1-\hat{y}) \qquad (3)$$

where n_1' is the number of salmon marked and $\hat{y}$ is the estimated proportion of marked fish that either died or left the system prior to spawning.

Consistency conditions *a* – *f* described in the previous section are germane to this estimator as well, except condition (*a*) now refers to adults. To provide evidence that (*a*) was met, two χ^2 tests were performed: (1) for equal marked fractions across sampling locations in the second event; and (2) equal probabilities of recapture in the second event independent of when fish had been marked. Because the null hypothesis in either test was not rejected, the pooled Petersen estimator (equation 3) was used to model the mark-recapture data. Hypotheses were tested separately using the SPAS software program (Arnason et al. 1996). We also tested the hypothesis that the marked fraction sampled in the second event did not vary with time.

The possibility of size- and sex-selective sampling was also investigated, because assumption (*a*) can be violated in this manner. The hypothesis that fish of different sizes were captured with equal probability was tested with two Kolmogorov-Smirnov (K-S) 2-sample tests ($\alpha = 0.1$) (Appendix A1). Sex-selective sampling was investigated, by using a χ^2 test to compare the number of males and females caught in the lower river with those caught on the spawning grounds.

If sex compositions differed significantly, either marking or spawning grounds samples alone could be used to estimate sex composition, although sex is more difficult to determine early in the season from external characteristics (Ericksen 1999).

Because sampling in the lower river spanned the known migratory timing of coho salmon into the Unuk River and continued without interruption, the study was essentially closed to recruitment (*b*). Condition (*c*) met with adjustments obtained from radiotelemetry. The effect of tag loss (*d*) was virtually eliminated by using the two secondary marks, and all fish captured during the second event were inspected for all marks (*e*). Double sampling (*f*) was avoided by marking all fish captured in the second event with the LLOP.

Variance, bias, and confidence intervals for $\hat{N}_e$ were estimated with modifications of bootstrap procedures in Buckland and Garthwaite (1991). A stochastic value $\hat{n}_1^*$ for $\hat{n}_1$ was obtained by first drawing a new number of fish with transmitters that failed to spawn from the binom ($\hat{y}$, k) where k is the number of fish with transmitters, such that $(1-\hat{y}^*) = [1-\text{binom}(\hat{y},k)/k]$. A bootstrap sample was drawn with replacement from a sample of size $\hat{N}_e^+$, using the empirical distribution defined by the capture histories (Table 2). A new set of statistics $\{\hat{n}_1^*, n_2^*, m_2^*\}$ was generated from each bootstrap sample, along with a new estimate for abundance $\hat{N}_e^*$. The procedure above was repeated a thousand times, creating the empirical distribution $\hat{F}(\hat{N}^*)$, which is an estimate of $\hat{F}(\hat{N}_e)$. The difference between the average $\hat{N}_e^*$ of bootstrap estimates and $\hat{N}_e$ is an estimate of statistical bias in the latter statistic (Efron and Tibshirani 1993). Confidence intervals were estimated from $\hat{F}(\hat{N}_e^*)$ with the percentile method (Efron and Tibshirani 1993). Variance was estimated as

$$\text{var}(\hat{N}_e^*) = (B-1)^{-1}\sum_{b=1}^{B}(\hat{N}_{eb}^* - \overline{\hat{N}}_e^*)^2 \qquad (4)$$

where B is the number of bootstrap samples.

Table 2.–Capture histories for coho salmon immigrating back to the Unuk River, 2002 (notation explained in text)**.**

Capture history	Sample size	Source of statistics
Number marked	1,746	n_1
Number marked that survived	1,497	$n_1(1-\hat{y})$
Estimated number that failed to move upriver	249	$n_1\hat{y}$
Estimated number marked, survived, and not sampled in tributaries	1,474	$\hat{n}_1 - m_2$
Estimated number marked, survived, and recaptured in tributaries	23	m_2
Not marked, but captured in tributaries	864	$n_2 - m_2$
Estimated number not marked and not sampled in tributaries	53,049	$\hat{N}_e - \hat{n}_1 - n_2 + m_2$
Effective population for simulations	53,659	$\hat{N}_e^+ = \hat{N}_e + n_1\hat{y}$

AGE, SEX, AND LENGTH

The proportion of the escapement composed of a given age was estimated as a binomial variable from fish sampled during the second event in the mark-recapture experiment to estimate adult abundance:

$$\hat{p}_j = \frac{n_j}{n} \qquad (5)$$

$$\text{var}(\hat{p}_j) = \frac{\hat{p}_j(1-\hat{p}_j)}{n-1} \qquad (6)$$

where $\hat{p}_j$ is the estimated proportion of the sample of age j, n_j is the number of coho salmon of age j, and n is the number of coho salmon sampled during the first event for which age was determined.

Sex composition and age-sex composition for the escapement and its associated variances were also estimated with the equations above by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_k$, where k denotes gender (male or female), such that $\sum_k \hat{p}_k = 1$, and by age-sex $\hat{p}_{jk}$, such that $\sum_{jk} \hat{p}_{jk} = 1$. Average lengths by age and sex were calculated using standard procedures.

ESTIMATING HARVEST

The 2002 harvest of coho salmon originating from the Unuk River was estimated from catch samples in U.S. and Canadian marine commercial and U.S. recreational fisheries. In 2002 several fisheries harvested coho salmon bound for the Unuk River, consequently harvest was estimated over several strata, each a combination of time, area, and fishery type. Statistics from the commercial troll fishery were stratified by fishing period and by fishing quadrant. Statistics for drift gillnet and seine fisheries were stratified by statistical week and by fishing district. Statistics from the recreational fishery were stratified by fortnight and location. Estimates of harvest $\hat{r}_i$ were calculated for each stratum and summed across strata to obtain an estimate of the total $\hat{T}$:

$$\hat{T} = \sum_i \hat{r}_i \tag{7}$$

$$\text{var}\left[\hat{T}\right] = \sum_i \text{var}\left[\hat{r}_i\right] \tag{8}$$

Variance of the sum of estimates was estimated as the sum of variances across strata, because sampling was independent across strata.

A subset of the catch (H_i) in each stratum was counted and inspected, to find fish missing their adipose fin. Of those a_i salmon in this sample without the adipose fin, heads were retrieved from a subset, marked, and sent to Juneau for dissection. Of the a_i' heads that arrived in Juneau, all were passed through a magnetometer to detect a CWT. Of the t_i tags detected, t_i' were successfully decoded under a microscope, after dissection of which m_i had come from the Unuk River (Appendix A2). Oliver (1990) and Hubartt et al. (1999) present details of sampling commercial and recreational fisheries, respectively. The fraction of the return having CWTs was estimated as $\hat{\theta} = m_e/n_e$, where m_e is the number of adults sampled at SN1 in 2002 that possessed valid CWTs and n_e is the total number of adults sampled at SN1 in 2002 (note that $n_e > n_1$). Information from catch and field sampling programs was expanded to estimate harvest and the associated variance of coho salmon bound for the Unuk River for each stratum, using methods and equations from Bernard and Clark (1996).

MEAN DATE OF HARVEST

Estimates of the mean dates of harvest for marine commercial and recreational fisheries were calculated from the time series of estimated proportions of catches by strata within a fishery following the methods of Mundy (1982):

$$\hat{P}_d = \frac{\hat{H}_d}{\sum_i H_i} \tag{9}$$

where P_d is the fraction of harvest realized in a fishery on day d. The mean date of harvest $\bar{d}$ in each fishery was calculated as

$$\hat{\bar{d}} = \sum_d d\hat{P}_d \tag{10}$$

RUN SIZE, EXPLOITATION RATE, AND MARINE SURVIVAL RATE

Estimates of run size (i.e., harvest and escapement) for coho salmon returning to the Unuk River in 2002 and the associated exploitation rate in marine recreational and commercial fisheries are based on the sum of the estimated harvest and escapement:

$$\hat{N}_R = \hat{T} + \hat{N}_e \tag{11}$$

The variance was estimated as the sum of the estimated variances for statistics on escapement and harvest:

$$\text{var}[\hat{N}_R] = \text{var}[\hat{T}] + \text{var}[\hat{N}_e] \tag{12}$$

An estimate of the exploitation rate for this stock and its estimated variance were calculated as

$$\hat{U} = \frac{\hat{T}}{\hat{N}_R} \tag{13}$$

$$\mathrm{var}\left[\hat{U}\right] \approx \frac{\mathrm{var}[\hat{T}]\,\hat{N}_e^2}{\hat{N}_R^4} + \frac{\mathrm{var}[\hat{N}_e]\,\hat{T}^2}{\hat{N}_R^4} \tag{14}$$

Estimates of marine survival rate of smolt to adults and its variance were calculated as

$$\hat{S} = \frac{\hat{N}_R}{\hat{N}_s} \tag{15}$$

$$\mathrm{var}[\,\hat{S}\,] \approx \hat{S}^2 \left[\frac{\mathrm{var}[\,\hat{N}_R\,]}{\hat{N}_R^2} + \frac{\mathrm{var}[\,\hat{N}_s\,]}{\hat{N}_s^2} \right] \tag{16}$$

Variances in equations (14) and (16) were approximated by the delta method (Seber 1982).

RESULTS

SMOLT CAPTURE, TAGGING, AND SAMPLING

Smolt trapping commenced on 31 March, tagging began on 1 April, and both activities ceased on 23 April. Ideal trapping conditions persisting throughout this period as the river remained low, effectively concentrating smolt, and resulting in relatively high trapping efficiency (Figure 6). Coho salmon smolt were the primary target species for the final 10 days of trapping. During this period the river experienced a slow steady rise in water level from increased snow melt, giving crew improved access to back sloughs and beaver ponds.

The crew tagged and released 11,960 (= M_1) small (70–82 mm FL) coho salmon smolt and 11,920 (= M_2) large (≥83 mm FL) smolt with CWTs. Between 1 April and 23 April 2001,

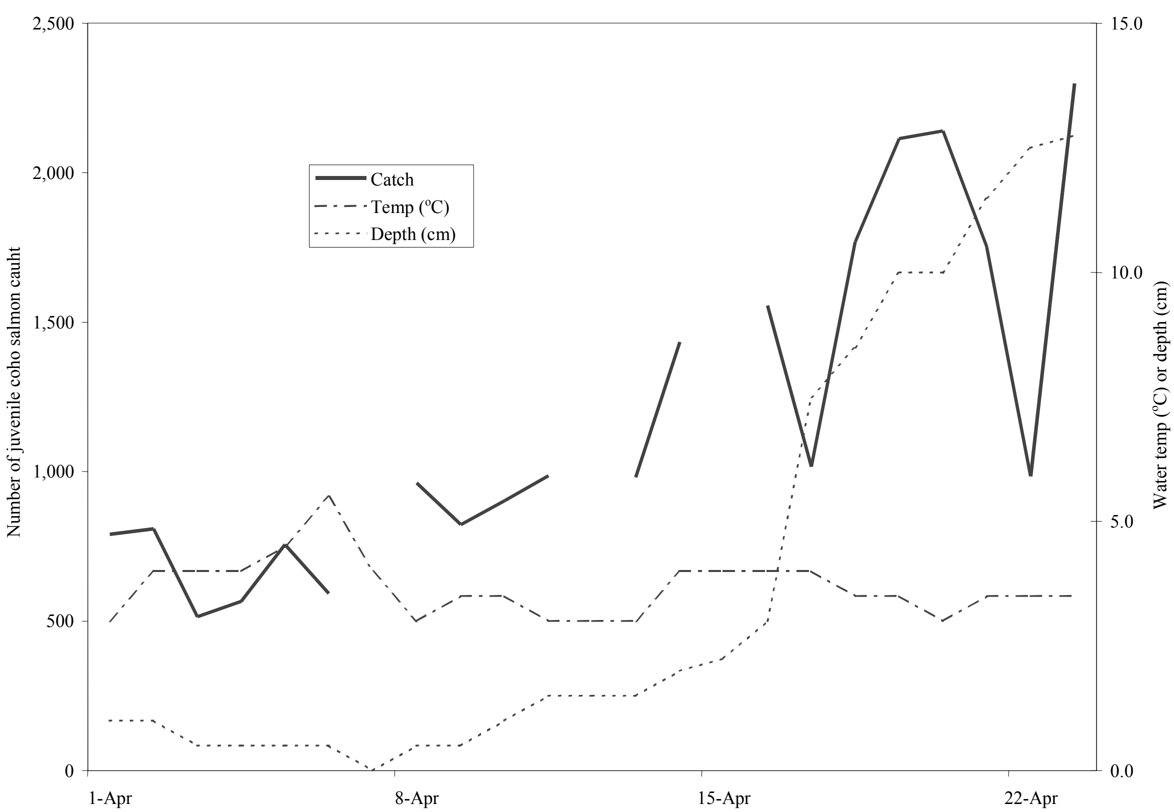

Figure 6.–Catches of coho salmon smolt ≥70 mm FL, daily water temperature, and water depth in the Unuk River, 2001.

11,720 small and 11,799 large coho salmon smolt were tagged with codes 04-02-89 and 04-02-90, respectively. Another 249 small coho smolt were captured on 23 April and tagged with code 04-02-91, and 130 large coho smolt tagged with code 04-02-92. Of the small coho salmon smolt tagged with code 04-02-89, 9 died overnight, leaving 11,711 valid tags released. No mortalities or shed tags were observed among tag code 04-02-91, and 11,960 small coho salmon smolt were thus released with valid tags (Table 3). No tags were shed by large coho salmon smolt; 9 died overnight (all code 04-02-90), resulting in a total release of 11,920 large salmon smolt with valid tags. Coho salmon smolt averaged 84.2 mm FL and 6.4 g in weight (Table 3; Figure 7).

Some 16,561 chinook salmon smolt were released, each with a CWT carrying code 04-10-45. Of the 16,565 chinook salmon smolt tagged, 4 died overnight; none lost their tags (Table 3; Figure 7). Tagged chinook smolt averaged 67.4 mm FL and 3.3 g in weight (Table 3; Figure 7). Detailed analysis of the data on chinook salmon will be reported in a separate document.

Table 3.–Number of salmon smolt caught and subsequently released with valid coded-wire tags on the Unuk River, 2001.

		Coho salmon			**Chinook salmon**			**Water conditions**	
Date	**Traps checked**	Number	Avg. length (mm FL)	Weight (g)	Number	Avg. length (mm FL)	Weight (g)	Temp. (°C)	Depth (cm)
1-Apr	91							3.0	1.0
2-Apr	93				1,924	68.13	3.20	4.0	1.0
3-Apr	81	1,600						4.0	0.5
4-Apr	89				1,861			4.0	0.5
5-Apr	120	1,081						4.5	0.5
6-Apr	94							5.5	0.5
7-Apr		1,350	87.25	6.52	2,475	66.58	3.10	4.0	0.0
8-Apr	138							3.0	0.5
9-Apr	118				2,263			3.5	0.5
10-Apr	109	1,784	82.63	6.01				3.5	1.0
11-Apr	119							3.0	1.5
12-Apr		1,891			1,955	67.24	3.14	3.0	1.5
13-Apr	143							3.0	1.5
14-Apr	209							4.0	2.0
15-Apr		2,415			2,247			4.0	2.3
16-Apr	147							4.0	3.0
17-Apr	96							4.0	7.5
18-Apr	167	4,342	83.90	6.28	1,753			3.5	8.5
19-Apr	166	2,114			487	69.58	3.96	3.5	10.0
20-Apr	185	2,139			523			3.0	10.0
21-Apr	157	1,751			414			3.5	11.5
22-Apr	148	984			375			3.5	12.5
23-Apr	126	2,429	83.14	6.43	284			3.5	12.8
Total	2,596	23,880			16,561				
Max.	209							5.5	12.8
Min.	81							3.0	0.0
Average	113		84.24	6.43		67.41	3.21	3.7	3.9
Number weighed/ measured			184	184		173	173		
		SD	11.13	2.51		5.51	0.83		
		SE	0.80	0.18		0.42	0.06		

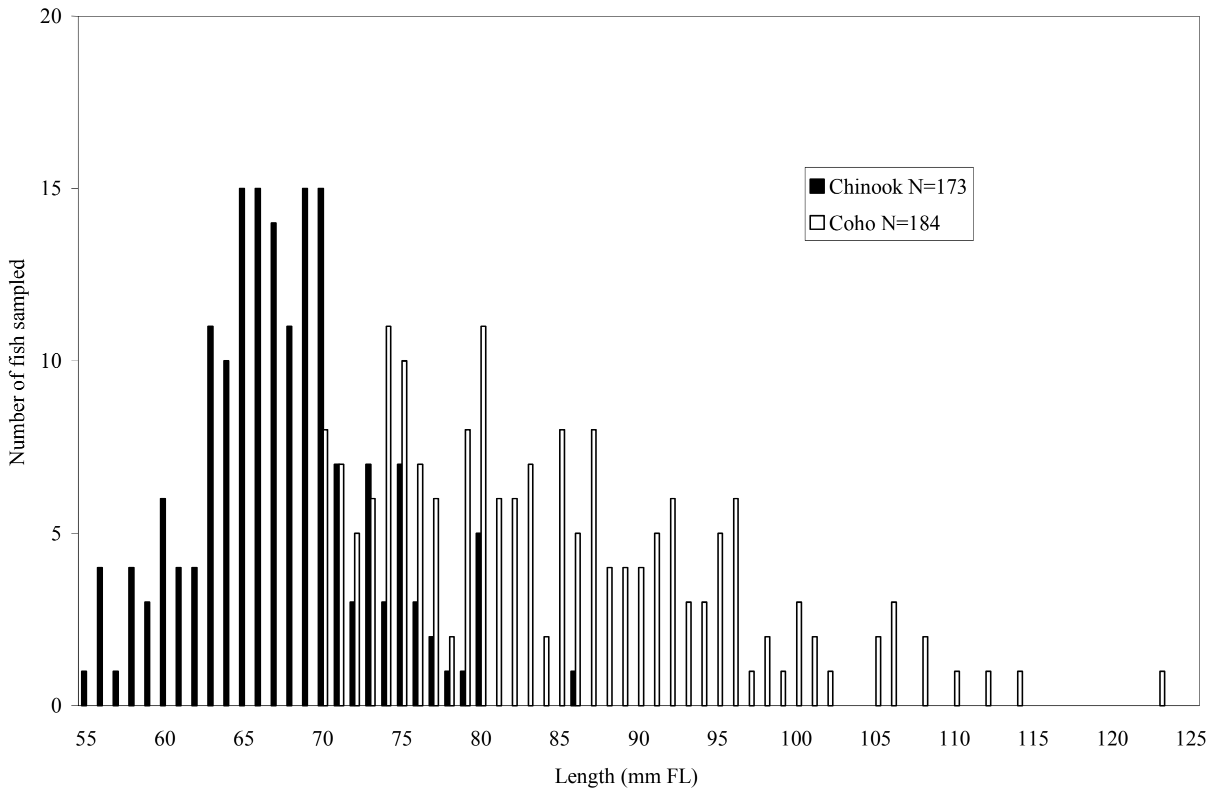

Figure 7.–Length frequency of coho salmon smolt ≥70 mm FL and chinook salmon smolt captured and measured in spring in the Unuk River, 2001.

SMOLT ABUNDANCE

The estimate of smolt abundance $\hat{N}_s^*$ for 2001 is 757,080 (SE = 142,167) after adjusting for size-selective capture of smolts. Of the 11,960 small smolts released with CWTs in 2001, 145 were recovered from adults taken in fisheries or sampled in the river a year later.

Of the 11,920 large smolts released, 60 were recovered in 2002. Recovery rates are significantly different ($\chi^2 = 35.84$, df = 1, $P < 0.000001$), implying that the survival rate for larger smolt was an estimated 2.425 times the rate for smaller smolt. Considering the age composition of all adults sampled at SN1 and those carrying CWTs, such a disparity in survival rates implies a disparity in capture rates for smolts as well (Appendix B1), with large smolts an estimated 2.12 $(= \hat{A})$ times more likely to have been tagged in 2001. This lower capture rate for smaller smolt is consistent with some, but not necessarily all, young salmon <70 mm smolting in 2001. Given that 65 smolt were recaptured inriver as adults from the 1,819 (= *C*) adults inspected at SN1, the unadjusted estimate is 658,537, about 14% lower than the unbiased estimate given above. Variance and statistical bias of the adjusted estimated were estimated through bootstrap simulations, with bias estimated at 0.3%.

RADIOTELEMETRY

Of the 49 adult coho salmon released with transmitters in 2002, 42 (85.7%) were subsequently found in the Unuk River or its tributaries and presumed to have spawned (Figure 8; Appendix A3). We consequently estimated $\hat{y}$ = 7/49, to adjust for the proportion of those fish tagged during the first event of the mark-recapture experiment which failed to successfully spawn in the Unuk River (as described in equation 3).

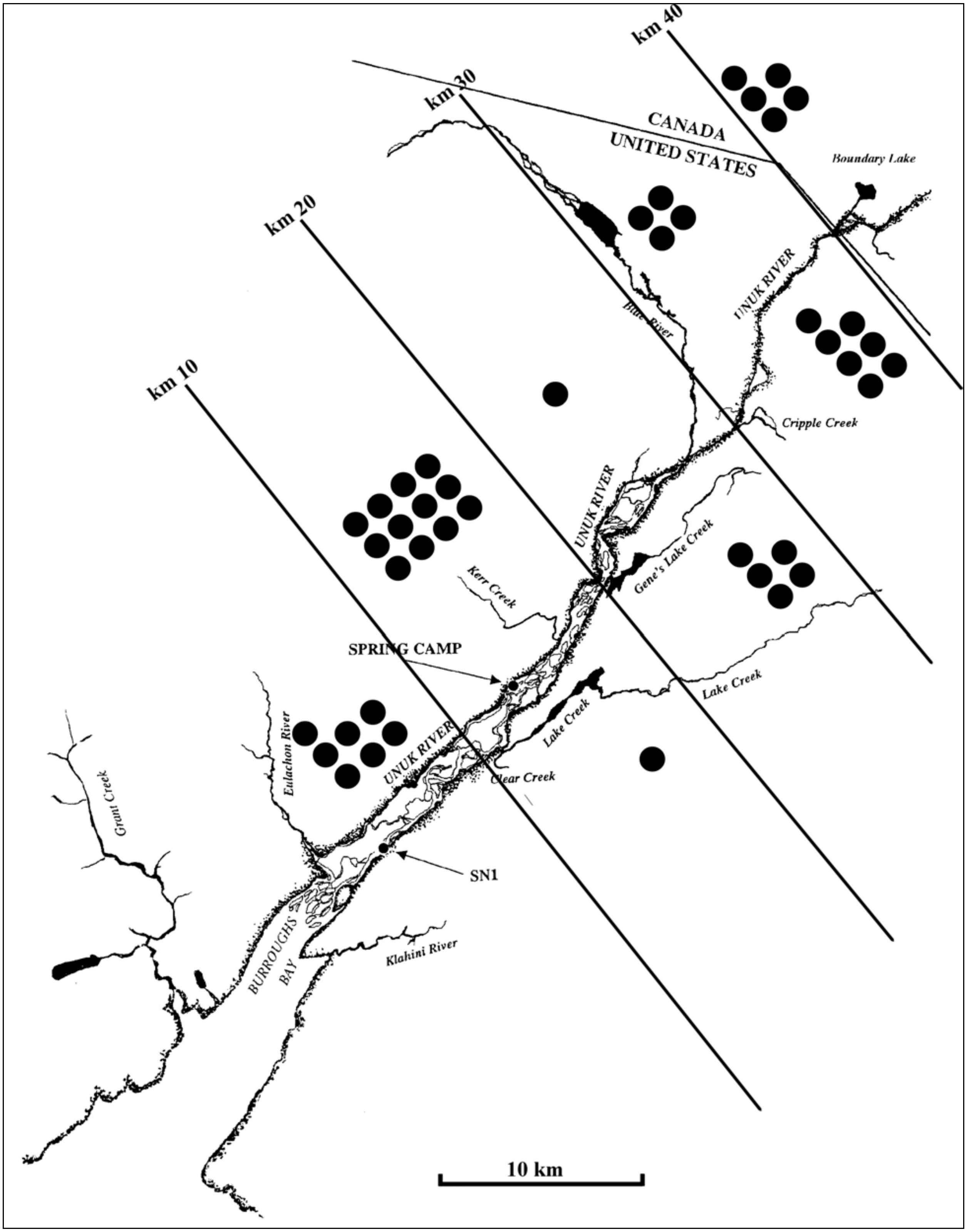

Figure 8.– Destinations of coho salmon fitted with radio transmitters in 2002 and the major spawning tributaries for coho salmon in the Unuk River. Each circle refers to the farthest upstream location identified for a radiotagged fish in 2002.

Coho salmon with radio transmitters were released between 17 August and 25 September and tracked from the Eulachon River to river km 63 on the Unuk River in Canada (Figure 8). Of the 42 fish presumed to have successfully spawned within the Unuk River watershed, 17% were tracked to the Eulachon River, 17% to Cripple Creek, 12% to Genes Lake, 10% to Boundary Lake, 7% to Kerr Creek, 5% to Lake Creek, and 33% were located in the main river. About 12% were ultimately located above river km 39 on the Canadian side of the border. Thirty-six (36) transmitters were recorded at or beyond river km 13 where the radio towers were located. Of these, 25 (69%) were recorded by both aerial surveys and tracking towers, while 6 (17%) were located solely by aerial surveys. Five (5) transmitters (14%) were only recorded as having reached river km 13 by the tracking towers, albeit aerial surveys did locate four of these tags downriver of the towers: two in the vicinity of Lake Creek, one in the Eulachon River, and the fourth several kilometers above SN1. No radiotagged fish were recaptured in the set gillnet at SN1. For the 7 radiotagged fish that presumably did not spawn in the Unuk River, 3 were never located and 4 were mortalities located at or near SN1.

ESCAPEMENT

The estimated escapement of coho salmon in the Unuk River in 2002 was 55,409 (SE = 12,084, $RP_{\alpha=0.05}$ = 43%). From bootstrapping, statistical bias in $\hat{N}_e$ was estimated at 4.4% and the 95% confidence interval for the estimate is 34,156 to 76,662. Of 1,819 coho salmon sampled during the first event, 1,746 were successfully marked and released (n_1), and 1,497 were estimated to have survived and spawned ($\hat{n}_1$) in the Unuk River (Table 4). Approximately 95% of the catch at SN1 occurred between 5 August and 25 September (Figure 9). Of the 73 fish not marked, 65 were sacrificed to find CWTs, 3 died in the nets, and 4 were marked but died shortly thereafter. Of the 887 coho salmon sampled during the second event (n_2), 23 (m_2) had spaghetti tags, and all of these had easily identifiable secondary marks. No fish were recaptured having lost their primary mark (tag). The largest samples from the second event were from the Eulachon River (440 fish with 9 recoveries), Boundary Creek (203 fish with 6 recoveries), Lake Creek (130 fish with 4 recoveries), and Genes Lake Creek (81 fish with 1 recovery). Fish were sampled on the spawning grounds from 14 August through 11 November. Seventeen (17) fish were missing adipose fins and were sacrificed, and each carried a CWT from tagging operations on the Unuk River in 2001.

With some exceptions, fishing effort during the first event was maintained at a relatively consistent level throughout the experiment (Figure 9). From 1 August to 28 September the set gillnets at SN1 were fished for 838 hours. High water and large amounts of debris precluded fishing the set gillnets on 9, 10, 13, 14, and 30 August, and on 1, 21, and 22 September. In addition, incessant rainfall caused the Unuk River to flood from 22 to 29 August (cresting at 5–6 feet above pre-flood levels), during which time all mark-recapture activities were suspended. The number of coho captured per hour, or catch per unit effort (CPUE), averaged approximately 2.2 during this period, with a maximum value of 12.4 on 4 September.

Sixty-five (65) coho salmon captured at SN1 and released during the first event were subsequently recaptured back at SN1; one was recaptured twice. The time elapsed between captures at SN1 (sulking time) averaged approximately 5.5 days (Appendix A4). The minimum sulking time was 12 minutes as opposed to a maximum of nearly 23 days. No coho salmon were captured at the upriver set gillnet sites which operated from 19 August to 25 August.

Results from hypothesis tests provided evidence that conditions had been met for getting a generally unbiased abundance estimate from the experiment. Coho salmon marked early in the experiment (before 6 September) and late in the experiment were equally likely to be recaptured (χ^2 = 0.23; df = 1; P = 0.64). Similarly, the recapture rate during the second event did not vary by sampling date (before or after 7 October; χ^2 = 0.16; df = 1; P = 0.69), or sampling location (downstream or upstream—i.e., Lake Creek, Kerr Creek, and the Eulachon River vs. Boundary Lake,

Table 4.–Number of marked coho salmon released in the Unuk River and recaptured by marking period and recovery location, and the number examined for marks at each recovery location, 2002.

Marking dates	Estimated number marked[a]	Estimated fraction recovered	RECOVERY LOCATION		
			Downriver	Upriver	Total
7/31–9/6	725	0.014	6	4	10
9/7–9/28	771	0.017	9	4	13
Total/average	1,497	0.015	15	8	23
Number inspected			600	287	887
Fraction marked			0.025	0.028	0.026

[a] Number marked discounted by the estimated proportion of unsuccessful inriver spawners (0.143), total includes rounding error.

Cripple Creek, and Genes Lake; $\chi^2 = 0.06$; df = 1; P = 0.81). These results are consistent with every fish having an equal chance of being marked at SN1 regardless of when they were caught.

Once on the spawning grounds, coho salmon did not have an equal chance of being sampled across the watershed. For instance, 17% of spawning fish with transmitters were tracked to the Eulachon River; however the Eulachon River

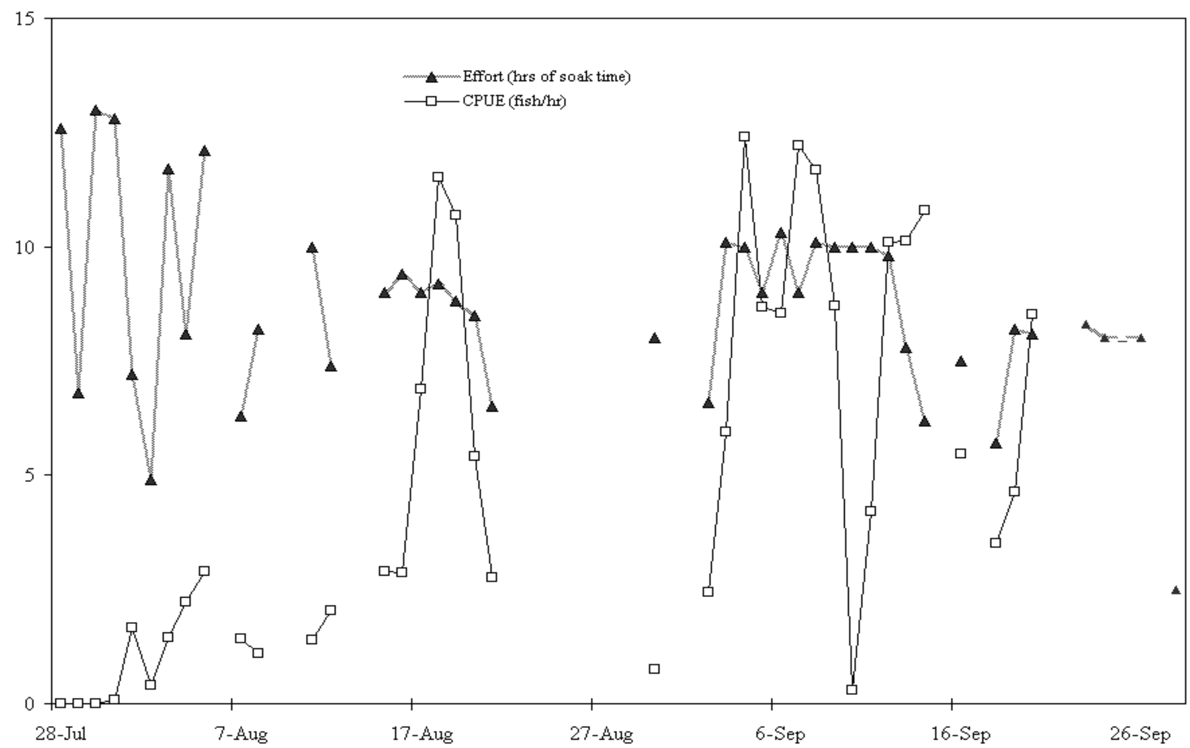

Figure 9.– Effort (in hours per day) and catch per unit effort (CPUE) of adult coho salmon at SN1 on the Unuk River, 2002.

constituted 49.6% of the sample from the second event. In addition, at least 33% of transmitters were tracked to mainstem spawning locations not sampled during the second event. Since sampling was demonstrably proportional during the first event, such disproportionate sampling during the second event had no effect on the accuracy of the abundance estimate.

Some size-selective sampling was detected, but not enough to compromise the estimate of abundance. The length distribution of fish captured during the first event in August varied noticeably from those captured in September (Figure 10). Even so, the length distributions of fish marked in the first event were not significantly different than the length distributions for fish recaptured in the second event ($P = 0.14$; Figure 11). Because this lack of significance might be attributed to low power in the test, the experiment was divided into small (≤600 mm MEF) and large (>600 mm MEF) fish, and estimates generated for each group. The sum of these two stratified estimates was less than two thousand fish larger than the unstratified estimate of 55,406. The length distributions of marked fish were significantly different from those of fish inspected on the spawning grounds ($P < 0.001$; Figure 12) indicating some size-selective sampling in the first event. Distribution of fish sampled on the spawning grounds was broader than the distribution of fish caught at SN1 with a dominance of larger fish. Such a dichotomy is expected given the selectivity of gillnets and the variety of gears used upstream to capture fish. Because size-selective sampling was indicated for the first event, but not the second, samples taken during the second event were used to estimate mean length of individuals. The largest fish sampled in the second event was 765 mm MEF, the smallest was 355 mm, and the mean was 591 mm (SE = 2.9 mm) (Appendix A5).

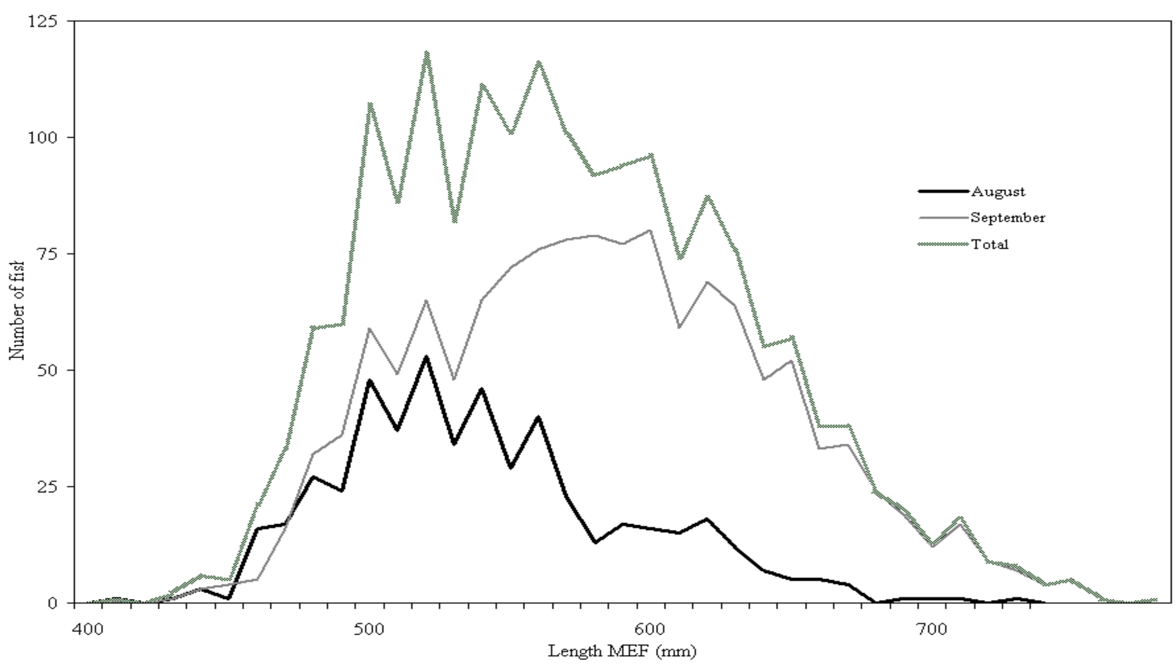

Figure 10.–Length frequency distributions of adult coho salmon sampled at SN1 on the Unuk River in August (sample size = 516) **and September** (sample size = 1,302)**, 2002.**

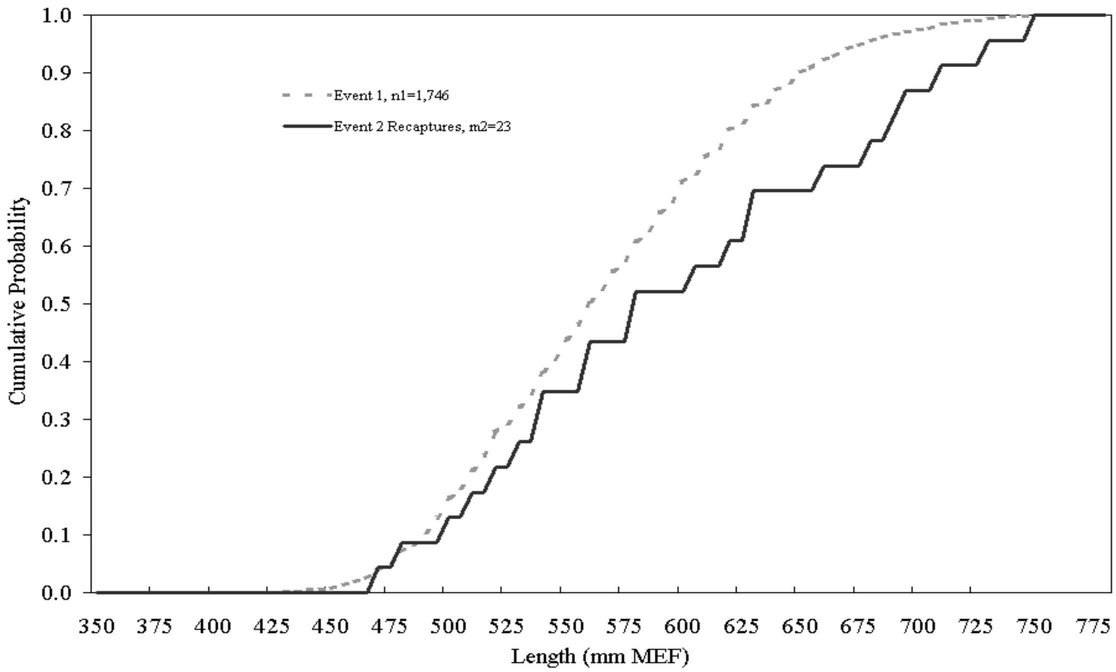

Figure 11.– Cumulative relative frequencies of adult coho salmon marked in the lower Unuk River in 2002 compared with those recaptured upstream.

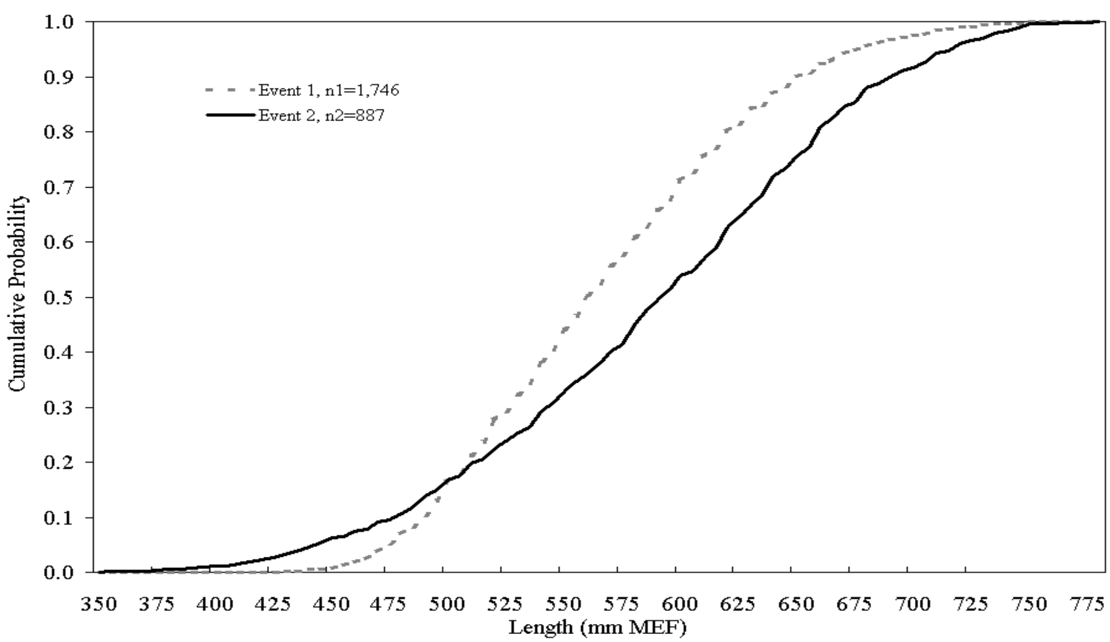

Figure 12.–Cumulative relative frequencies of adult coho salmon marked in the lower Unuk River in 2002 compared with those inspected upstream.

AGE, SEX, AND LENGTH

Age-1.1 fish accounted for an estimated 81.7% (SE = 0.8%) and age-2.1 fish for 18.3% (SE = 0.8) of escapement, of which an estimated 50.5% (SE = 1.0%) were males (Table 5) (Appendix A5). Tests showed no significant differences in sex composition (χ^2 = 0.32; df = 1; P = 0.57) or age composition (χ^2 = 2.37; df =1; P = 0.12) between events. For this reason samples from both events were pooled to calculate the statistics above. Of the 2,706 fish sampled in both events, ages were determined for 2,313 (about 85%). No significant difference was observed in the age composition of coho salmon captured at SN1 or upstream on the spawning grounds (P ≥ 0.51). For the escapement, an estimated 45,281 (SE = 9,884) were age-1.1 and 10,129 (SE = 2,251) were age-2.1 with 27,955 (SE = 8,583) estimated to be males (Table 5).

HARVEST, MEAN DATE OF HARVEST, RUN SIZE, EXPLOITATION RATE, AND MARINE SURVIVAL RATE

An estimated 15,584 (SE = 12,084) coho salmon originating from the Unuk River were harvested in marine commercial and recreational fisheries in 2002 throughout Southeast Alaska (Table 6).

These fish were harvested primarily from the Southeast (67%) and Northwest (20%) quadrants (Appendix A6). In 2002, 145 coho salmon with CWTs released in the Unuk River in 2001, and 2 coho salmon released with CWT's in 2000, were recovered from various U.S. marine fisheries as random recoveries in the port and creel census sampling programs. In addition, 2 fish tagged in 2001 were recovered in northern British Columbia from randomly sampled marine fisheries. Seventy-five (75) recoveries were from escapement sampling (74 were tagged in 2001 and 1 in 2000) (Appendix A2). Of the 1,819 fish sampled at SN1, 66 were missing adipose fins; 4 of these had no tags and 1 carried a Unuk River CWT implanted in 2000. The fraction of fish sampled at SN1 with valid 2001 CWTs was estimated to be 0.0335 (SE = 0.0042).

Coho salmon from the Unuk River stock constituted an estimated 1.4% of the harvest of that species in the troll fishery, 4.7% and 2.0% of harvests in the seine and Metlakatla Indian Community (MIC) drift gillnet fisheries of District 101, and 3.6% and 0.2% of harvests in recreational fisheries near Ketchikan and Sitka (Table 7; Appendix A7). Expansion of the two CWTs recovered British Columbia arrival of fishery catch and sampling information.

Harvests in troll and recreational fisheries were relatively protracted (i.e., July through September), whereas 56% of the harvest in the seine fishery occurred during one week (25–31 August). The estimated mean date of harvest in the troll fishery was 18 August, compared to 29 August

Table 5.–Estimated age and sex composition of escapement, harvest, and run of the Unuk River stock of coho salmon, 2002. Estimates based on combined samples collected during both events.

		Age		
		1.1	2.1	Total
Female	n_k	938	214	1,152
	$\hat{p}_{jk}$ (100%)	40.3	9.2	49.5
	SE (%)	1.0	0.6	1.0
	Escapement	22,354	5,100	27,454
	SE (escapement)	4,906	1,159	8,506
	Harvest	6,287	1,434	7,722
	SE (harvest)	835	209	1,431
	Female run size	28,742	6,557	35,299
	SE (female run size)	4,995	1,204	8,625
Male	n_k	962	211	1,173
	$\hat{p}_{jk}$ (100%)	41.4	9.1	50.5
	SE (%)	1.0	0.6	1.0
	Escapement	22,926	5,029	27,955
	SE (escapement)	5,030	1,143	8,583
	Harvest	6,448	1,414	7,862
	SE (harvest)	856	206	1,444
	Male run size	29,478	6,465	35,943
	SE (male run size)	5,120	1,188	8,704
Total	n	1,900	425	2,325
	$\hat{p}_j$ (100%)	81.7	18.3	100.0
	SE (%)	0.8	0.8	
	Escapement	45,281	10,129	55,409
	SE (escapement)	9,884	2,251	12,084
	Harvest	12,735	2,849	15,584
	SE (harvest)	1,666	392	2,033
	Run size	58,220	13,023	71,242
	SE (run size)	10,029	2,309	12,253

Table 6.–Estimated marine harvest of adult coho salmon bound for the Unuk River in 2002 (V(θ) = 14 and G(1/θ) = 0.018).

TROLL FISHERY

Stat. week	Date	Period	Quadrant	N	v(N)	n	a	a'	t	t'	mc	r^	SE(r^)	RP(r^)	VAR(r^)
27–32	6/30–8/10	3	SE	65,133	–	24,561	475	469	372	372	10	801	269	66%	72,508
33–40	8/11–10/5	4	SE	115,925	–	53,402	1,092	1,075	876	875	27	1,777	404	45%	163,490
27–32	6/30–8/10	3	SW	89,753	–	58,581	612	604	460	460	9	417	146	69%	21,323
33–40	8/11–10/5	4	SW	50,368	–	35,540	518	511	407	407	10	428	143	66%	20,549
27–32	6/30–8/10	3	NE	102,015	–	35,428	1,363	1,351	1,200	1,197	5	434	199	90%	39,675
33–40	8/11–10/5	4	NE	82,886	–	26,757	866	857	739	737	4	374	191	100%	36,339
27–32	6/30–8/10	3	NW	341,306	–	113,254	2,224	2,210	1,845	1,844	10	905	304	66%	92,664
33–40	8/11–10/5	4	NW	461,263	–	125,974	3,234	3,201	2,819	2,817	20	2,208	561	50%	314,958
Subtotal troll fishery				1,308,649	–	473,497	10,384	10,278	8,718	8,709	95	7,345	873	23%	761,506

SEINE FISHERY

Stat. week	Date	District	N	v(N)	n	a	a'	t	t'	mc	r^	SE(r^)	RP(r^)	VAR(r^)
31	7/28–8/3	101	6,926	0	1,853	62	60	55	55	1	115	115	195%	13,151
34	8/18–8/24	101	11,854	0	1,367	26	26	22	22	2	517	368	139%	135,341
35	8/25–8/31	101	8,956	0	320	7	6	5	5	2	1,947	1,387	140%	1,924,225
31	7/28–8/3	102	10,647	0	802	10	10	8	8	1	396	395	196%	156,326
36	9/1–9/7	102	2,519	0	371	4	4	4	4	1	202	202	196%	40,794
32	8/4–8/10	104	1,155	0	413	4	4	4	4	1	83	83	195%	6,872
31	7/28–8/3	109	44,672	0	5,731	62	62	52	51	1	237	237	196%	55,934
Subtotal seine fishery			86,729	0	10,857	175	172	150	149	9	3,498	1,527	86%	2,332,643

RECREATIONAL FISHERY

Biweek	Date	Derby area	N	v(N)	n	a	a'	t	t'	mc	r^	SE(r^)	RP(r^)	VAR(r^)
13	6/24–7/7	Ketchikan	2,194	482,449	519	65	65	59	59	1	126	126	195%	15,779
16	8/5–8/18	Ketchikan	4,975	1,977,143	1,204	17	17	13	13	1	123	123	195%	15,071
17	8/19–9/1	Ketchikan	5,116	916,237	1,233	32	31	27	27	2	255	184	142%	34,023
18	9/2–9/15	Ketchikan	8,416	2,928,982	3,073	79	75	63	63	5	430	212	97%	44,963
19	9/16–9/29	Ketchikan	4,901	805,802	1,580	55	55	49	49	3	277	167	118%	27,912
17	8/19–9/1	Sitka	7,463	2,889,851	2,907	107	105	93	93	1	78	78	195%	6,013
Subtotal recreational fishery			33,065	10,000,464	10,516	355	348	304	304	13	1,290	379	58%	143,761

-continued-

Table 6.–Page 2 of 2.

GILLNET FISHERY

Stat. week	Date	District	N	v(N)	n	a	a'	t	t'	mc	r^	SE(r^)	RP(r^)	VAR(r^)
32	8/4–8/10	106	9,319	0	1,894	33	33	26	26	1	147	146	195%	21,383
33	8/11–8/17	106	11,248	0	5,390	71	71	54	54	2	124	88	139%	7,745
34	8/18–8/24	106	15,981	0	3,514	34	34	26	26	1	136	135	195%	18,258
35	8/25–8/31	106	13,432	0	4,424	50	50	38	38	1	91	90	195%	8,108
36	9/1–9/7	106	40,552	0	8,494	89	87	77	76	3	443	259	115%	66,952
37	9/8–9/14	106	33,750	0	8,156	242	241	203	203	5	620	285	90%	81,023
38	9/15–9/21	106	23,096	0	6,021	176	176	151	151	2	229	162	139%	26,358
39	9/22–9/28	106	18,176	0	5,269	192	192	167	167	4	411	210	100%	43,934
31	7/28–8/3	101	2,331	0	833	13	13	12	12	1	83	83	195%	6,881
33	8/11–8/17	101	2,086	0	1,200	32	24	23	23	1	69	69	195%	4,709
37	9/8–9/14	101*	10,385	0	564	45	45	43	43	2	1,098	782	140%	611,440
Subtotal gillnet fishery			180,356	0	45,759	977	966	820	819	23	3,450	947	54%	896,790
TOTALS			1,608,799	10,000,464	540,629	11,891	11,764	9,992	9,981	140	15,584	2,033	26%	4,134,701

* Indicates MIC

Table 7.–Estimated marine harvest, exploitation rate, run size, and marine survival rate of the Unuk River stock of coho salmon, 2002.

Fishery	Area	Estimated harvest	SE	Percent of marine harvest	Percent of run size
Troll	SE Quadrant	2,578	674	16.5%	3.6%
	SW Quadrant	845	289	5.4%	1.2%
	NE Quadrant	809	1,198	5.2%	1.1%
	NW Quadrant	3,113	866	20.0%	4.4%
	Subtotal	7,345	873	47.1%	10.3%
Purse seine	District 101	2,580	1,870	16.6%	3.6%
	District 102	598	597	3.8%	0.8%
	District 104	83	83	0.5%	0.1%
	District 109	237	237	1.5%	0.3%
	Subtotal	3,498	1,527	22.4%	4.9%
Recreational	Ketchikan	1,212	812	7.8%	1.7%
	Sitka	78	78	0.5%	0.1%
	Subtotal	1,290	379	8.3%	1.8%
Drift gillnet	District 101	153	152	1.0%	0.2%
	District 101 MIC	1,098	782		1.5%
	District 106	2,200	1,375	14.1%	3.1%
	Subtotal	3,450	947	22.1%	4.8%
	All fisheries total	15,584	2,033	100.0%	21.9%
	Mark-recapture tagging mortality	249	–		0.3%
	Escapement	55,409	12,084		77.8%
	Run size	71,242	12,253		100.0%
	Estimated marine survival rate	9.4%	2.4%		
	Estimated exploitation rate	21.9%	4.3%		

and 3 September for the recreational and gillnet fisheries (Appendix A6). The overall mean harvest date in 2002 was 22 August, roughly two weeks later than the average mean harvest date from 1998 to 2001 (Figure 13; Appendix A7) (Jones et al. 1999, 2001a, 2001b; Weller et al. 2002). The first marine recovery of a CWT occurred on 5 July in the Northwest Quadrant of the troll fishery while the last marine recoveries of the year occurred in the Northwest Quadrant of the same fishery and in the recreational fishery near Ketchikan on 29 September. Of the 153 random and select recoveries in marine waters, 6.5% occurred after 19 September and 2% after 28 September.

The estimated exploitation rate in marine commercial and recreational fisheries was 21.9% (SE = 4.3%; Table 7). This exploitation rate was less than half that observed from 1998 to 2001, and the Northwest Quadrant troll fishery accounted for only 20% of the estimated marine harvest in 2002—in contrast to an average of 35% from 1998 to 2001 (Jones et al. 1999, 2001a, 2001b, Weller et al. 2002).

An estimated 71,242 (SE = 12,253) coho salmon in the Unuk River stock returned in 2002. The estimated marine survival rate was 9.4% (SE = 2.4%; Table 7), similar to what was observed in 1999 (9.8%; SE = 2.9%) (Jones et al. 2001a).

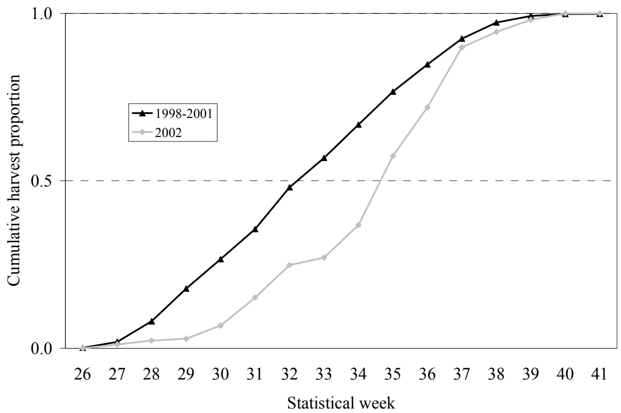

Figure 13.–Estimated cumulative marine harvest of the Unuk River stock of coho salmon by statistical week in 2002, versus the 1998–2001 average.

DISCUSSION

Results from studies similar to ours conducted from 1998 to 2001 (Jones et al. 1999, 2001a, 2001b; Weller et al. 2002) and since 1997 with chinook salmon (Jones et al. 1998; Jones and McPherson 1999, 2000; Weller and McPherson 2003) suggest that fish bound for the various spawning tributaries of the Unuk River can be proportionately sampled using set gillnets operated at SN1. The radiotelemetry data (Appendix A3; Figure 8) are that coho salmon distribute throughout the drainage after release. During 3 of the 4 previous years, operations at SN1 continued through the first week of October, after which catches were deemed negligible and operations ceased. In 2002, the set gillnets were operated through 28 September; after which time low water levels precluded access to the site. Recovery of CWTs in marine fisheries and CPUE at SN1 suggests that a proportionately small segment of the latter portion of the run was not sampled in 2002, as was also the case in 2001. So long as this "missed" portion of the run proportionately represented all spawning populations in the Unuk River, estimates of adult abundance are unbiased from early termination of operations at SN1.

Using set gillnets to capture coho salmon remains the cause of size-selective sampling at SN1. In the first three years of this study, two 5¾" set gillnets were used to capture fish. Results from these studies suggest that these nets were likely size-selective for larger coho salmon (Jones et al. 1999, 2001a, 2001b). In 2001 and 2002, a 4½" net was substituted for one of the larger mesh nets to correct this size-selectivity. Cumulative length frequencies of fish tagged at SN1 versus fish examined during the second event in 2001 and now in 2002 indicate that SN1 was now size-selective for mid-sized coho salmon in both 2001 and 2002. As noted, operations at SN1 were terminated earlier than anticipated (28 September versus 7 October) and prior to the end of the migration. The last, unsampled segment of the immigration was likely composed predominantly of larger fish (Figure 9), making the early termination of operations one reason for the significant difference observed in the relative size frequency distribution of fish sampled during both events.

Estimates of smolt abundance in the Unuk River for 1998–2001 are perhaps biased to some unknown extent. Studies in those years lacked the means to detect size-specific differences in capture rates or marine survival rates of smolts. Existence of both differences in a single mark-recapture experiment implies estimates would be biased low. Smolt emigrating from the Eulachon River are less likely to be captured and marked as they tend to rear beyond the confines of our trapping area (Lava Falls to tidal influence on the main stem and its adjoining sloughs). In addition, some proportion of the juvenile coho salmon that were less than 70 mm FL in the spring of 2001 and consequently had no chance of being marked, undoubtedly migrated to sea that spring. Finally, the survival rate of larger marked smolt was roughly 2.5 times that of smaller marked smolt (Appendix B.1). The bias involved in the estimate of smolt abundance in this study is 14%. Speculation is that such bias, if present in statistics from previous years, would be of similar magnitude.

Operation of set gillnets at SN1 to capture chinook salmon has proven to provide a good indicator of the commencement of the immigration of coho salmon. The earliest date a coho salmon has been captured at SN1 was on July 26 in 1999 during operations for chinook salmon. In 2002, the first coho salmon were captured on 31 July, the final day of the chinook salmon project. It is therefore likely that the first event sampling began early enough to avoid missing a significant number of migrating coho salmon. This ongoing study is designed to estimate escapement, harvest, run, marine survival rate, and exploitation rate of the Unuk River stock of coho salmon. During the previous four years, estimated run size ranged from 31,740 to 68,080 and averaged 53,1995 fish. This year total run was estimated to be 71,242 fish. Estimated smolt production of 757,080 in the spring of 2001 and the estimated marine survival rate of 9.4% were approximately 10 and 15 percent greater, respectively, than the average of the previous four years. Data gathered in five years of study on Unuk River coho salmon suggest that marine survival is probably the most important factor in determining adult coho salmon production.

Although coho salmon in southern southeast Alaska generally have the highest exploitation rates in the region, the exploitation rate in 2002 was only estimated to be 22%, down from the average rate of 57% for the previous four years. This drop is thought to be a consequence of the longest July opening of the troll fishery for chinook salmon in recent years, less fishing effort due to poor dockside prices, and other related factors (Lynch et al. 2003). The relatively low proportion of the Unuk River stock harvested in the Northwest Quadrant relative to previous years, and the relatively late mean date of harvest are also likely consequences of these factors.

CONCLUSION AND RECOMMENDATIONS

We recommend the following strategies for continued success of this project on the Unuk River in upcoming years.

Aerial telemetry surveys as well as remote radio towers need to continue, as neither method has proven failsafe for tracking fish. Hand-held receivers were used effectively, albeit sporadically, in 2001 to locate salmon. In 2002 the sole hand-held receiver was damaged and therefore not used. In 2003 the use of a hand-held receiver during ground surveys should be routine, as the unaccounted fraction of transmitters is a crucial component to accurately and precisely estimating escapement.

At least 25,000 smolt should be tagged annually to attain an estimate of abundance with a relative precision of 40% or better. In most years, such precision can be accomplished by running the smolt-tagging project longer, thus covering a greater proportion of the smolt emigration. Typically, catches of smolting chinook salmon decline dramatically by the end of April whereas catches of coho salmon remain consistent or increase. Thus, concentrating efforts to capture coho salmon after this time should boost the numbers such that more tags are recovered from fisheries in the following year. In addition, the practice of tagging smaller and larger smolt with separate codes needs to continue if relatively unbiased estimates of smolt abundance are to be obtained.

Fishing effort at SN1 and sampling effort upstream should be increased to improve precision of estimated escapement. Set gillnets at SN1 were fished for an average of 30, 28, and 45 hours per week, respectively, in 1999, 2000, and 2001. The goal in 2002 was to average 60 hours of fishing time per week at SN1 to increase the number of marked fish released; however, an average of 46 hours was actually achieved (excluding statistical week 32 where flooding precluded fishing). Also, operations at SN1 were prematurely halted on 28 September in 2002 because of low water and consequent logistical problems. Of the best available upriver locations for use as set gillnet sites during the second event, all proved undesirable because of excessive current, underwater snags, or absence of coho salmon. Effort was therefore redirected to focus on capturing fish on the spawning grounds, and the upriver set gillnet effort was abandoned. To this end, a highly successful 3-day sampling trip to Boundary Creek was accomplished in early November (180 coho salmon inspected and 6 tags recovered). Despite problems, and due in large part to the largest escapement in the five years of this project, the relative precision of the abundance estimate was 43%; the goal was 40%. We therefore recommend that a more realistic goal of 50 hours of fishing time per week at SN1 be established through the first week of October to ensure that the run is proportionally sampled and that an adequate number of tags are released.

We further recommend that the goal of finding a suitable upriver site to fish set gillnets be continued. Fishing at such an upriver site would increase the number of fish examined during the second event as well as provide a more representative sample of the population. The extremely dynamic nature of the Unuk River makes this possibility likely; however, if as in 2001 and 2002 promising sites prove unproductive, effort needs to be redirected in a timely fashion to the spawning grounds in general and to Boundary Creek in early November in particular.

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APPENDIX A

Appendix A1.–Detection of size-selectivity in sampling and its effects on estimation of abundance and on age and size composition.

RESULTS OF HYPOTHESIS TESTS, K-S AND χ^2 on lengths of fish

MARKED during the first sampling event **RECAPTURED** during the second event	**MARKED** during the first sampling event and **INSPECTED** during the second event
Case I: Accept H_O	Accept H_O
There is no size-selectivity during either sampling event.	
Case II: Accept H_O	Reject H_O
There is no size-selectivity during the second event, but there is during the first.	
Case III: Reject H_O	Accept H_O
There is size-selectivity during both sampling events.	
Case IV: Reject H_O	Reject H_O
There is size-selectivity during the second event; the status of size-selectivity during the first is unknown.	

Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second event to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data (p. 17).

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, ages, and sexes from only the second event to estimate proportions in compositions, and apply formulae to correct for size bias to the data from the second event.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling (Case III or IV), there is still a chance that the bias in estimates of abundance from this phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Cases III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and analysis can proceed as if there were no size-selective sampling during the second event (Cases I or II).

Appendix A2.– Random and select recoveries of coded-wire tags (CWTs) from the Unuk River stock of coho salmon, 2002.

Head number	Tag code	Gear	Recovery date	Stat. week	Quad.	Dist.	Length	Port survey Site	Sample number
					RANDOM RECOVERIES				
169262	40290	Troll	7/22/2002	30	NE	109	735	Port Alexander	2080032
506505	40290	Troll	7/26/2002	30	NE	109	545	Petersburg	2050501
231432	40289	Troll	7/27/2002	30	NE	109	651	Port Alexander	2080052
231551	40290	Troll	7/30/2002	31	NE	109	610	Port Alexander	2080056
216956	40290	Troll	8/1/2002	31	NE	109	667	Port Alexander	2080068
234060	40290	Troll	8/15/2002	33	NE	109	646	Port Alexander	2080095
234217	40290	Troll	8/20/2002	34	NE	109	695	Port Alexander	2080113
234229	40290	Troll	8/20/2002	34	NE	109	695	Port Alexander	2080115
216260	40289	Troll	9/2/2002	36	NE	109	639	Port Alexander	2080137
185635	40290	Troll	7/5/2002	27	NW	113	635	Sitka	2030689
185880	40289	Troll	7/6/2002	27	NW	157	628	Sitka	2030724
209830	40290	Troll	7/19/2002	29	NW	113	637	Pelican	2010209
38869	40290	Troll	7/24/2002	30	NW		735	Excursion Inlet	2100046
213188	40289	Troll	7/24/2002	30	NW	113	637	Sitka	2030917
218583	40290	Troll	7/25/2002	30	NW	113	645	Hoonah	2110178
218659	40290	Troll	7/31/2002	31	NW	113	710	Hoonah	2110185
214558	40290	Troll	8/4/2002	32	NW	154	642	Sitka	2030986
213666	40290	Troll	8/6/2002	32	NW	113	615	Sitka	2031006
218771	40289	Troll	8/9/2002	32	NW	114	615	Hoonah	2110198
218874	40290	Troll	8/18/2002	34	NW	113	715	Hoohah	2110210
218910	40290	Troll	8/21/2002	34	NW	113	600	Hoonah	2110213
210346	40259 [a]	Troll	8/26/2002	35	NW	113	555	Pelican	2010270
214361	40289	Troll	8/26/2002	35	NW	113	626	Sitka	2031146
215432	40290	Troll	8/26/2002	35	NW	113	720	Sitka	2031154
215469	40290	Troll	8/26/2002	35	NW	113	680	Sitka	2031156
210734	40290	Troll	9/3/2002	36	NW	113	704	Pelican	2010296
215958	40289	Troll	9/4/2002	36	NW	113	641	Sitka	2031226
216542	40290	Troll	9/4/2002	36	NW	113	690	Sitka	2031221
216559	40290	Troll	9/4/2002	36	NW	113	780	Sitka	2031222
236057	40290	Troll	9/4/2002	36	NW	113	747	Sitka	2031231
236717	40289	Troll	9/7/2002	36	NW	113	711	Sitka	2031240
210638	40289	Troll	9/9/2002	37	NW	113	612	Pelican	2010308
236488	40289	Troll	9/9/2002	37	NW	113	647	Sitka	2031245
236345	40289	Troll	9/13/2002	37	NW	113	671	Sitka	2031256
236384	40289	Troll	9/13/2002	37	NW	113	588	Sitka	2031258
236829	40290	Troll	9/14/2002	37	NW	113	620	Sitka	2031260
89960	40289	Troll	9/16/2002	38	NW	189	730	Petersburg	2051030
237201	40290	Troll	9/20/2002	38	NW	113	726	Sitka	2031277
236961	40290	Troll	9/29/2002	40	NW	113	751	Sitka	2031301
70000	40289	Troll	7/24/2002	30	SE	105	614	Ketchikan	2060250
78179	40290	Troll	7/29/2002	31	SE	101	535	Ketchikan	2060270
79837	40290	Troll	8/2/2002	31	SE	105	645	Craig	2070248
78841	40289	Troll	8/6/2002	32	SE	105	634	Ketchikan	2060312
506662	40290	Troll	8/6/2002	32	SE	105	524	Petersburg	2050645
79450	40290	Troll	8/7/2002	32	SE	105	684	Craig	2070277
506674	40290	Troll	8/7/2002	32	SE	105	501	Petersburg	2050654
78905	40290	Troll	8/9/2002	32	SE	105	541	Ketchikan	2060329
78955	40289	Troll	8/10/2002	32	SE	101	675	Ketchikan	2060332
91822	40290	Troll	8/10/2002	32	SE	105	670	Craig	2070286
90102	40289	Troll	8/17/2002	33	SE		605	Petersburg	2050792
77593	40290	Troll	8/20/2002	34	SE	101	649	Ketchikan	2060396

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Head number	Tag code	Gear	Recovery Date	Stat. week	Quad.	Dist.	Length	Port survey site	Sample Number
234170	40290	Troll	8/20/2002	34	SE	105	660	Port Alexander	2080109
77547	40290	Troll	8/21/2002	34	SE	105	610	Ketchikan	2060397
81937	40290	Troll	8/21/2002	34	SE	105	673	Craig	2070354
69548	40290	Troll	8/24/2002	34	SE	105	688	Craig	2070365
62728	40290	Troll	8/25/2002	35	SE	105	645	Craig	2070372
81847	40290	Troll	8/25/2002	35	SE	105	608	Craig	2070369
81850	40290	Troll	8/25/2002	35	SE	105	735	Craig	2070369
89215	40289	Troll	8/26/2002	35	SE	106	555	Petersburg	2050874
77694	40290	Troll	8/29/2002	35	SE	105	693	Ketchikan	2060431
89395	40290	Troll	8/29/2002	35	SE	105	751	Petersburg	2050915
89424	40290	Troll	8/29/2002	35	SE	105	706	Petersburg	2050915
66759	40290	Troll	8/30/2002	35	SE	101	665	Ketchikan	2060435
68737	40290	Troll	9/3/2002	36	SE	105	552	Craig	2070415
77897	40290	Troll	9/3/2002	36	SE	105	660	Ketchikan	2060443
77898	40290	Troll	9/3/2002	36	SE	105	648	Ketchikan	2060443
513071	40289	Troll	9/3/2002	36	SE	105	558	Ketchikan	2060443
514607	40291	Troll	9/11/2002	37	SE	105	611	Ketchikan	2060488
514610	40290	Troll	9/11/2002	37	SE	105	589	Ketchikan	2060488
514622	40290	Troll	9/11/2002	37	SE	105	718	Ketchikan	2060487
514703	40290	Troll	9/12/2002	37	SE	101	687	Ketchikan	2060495
514856	40290	Troll	9/16/2002	38	SE	101	761	Ketchikan	2060497
514858	40290	Troll	9/16/2002	38	SE	101	708	Ketchikan	2060497
514925	40290	Troll	9/17/2002	38	SE	105	754	Ketchikan	2060513
514766	40290	Troll	9/18/2002	38	SE	101	640	Ketchikan	2060517
516639	40290	Troll	9/23/2002	39	SE	105	686	Petersburg	2051073
73682	40290	Troll	7/11/2002	28	SW	104	601	Craig	2070109
79813	40290	Troll	7/31/2002	31	SW	152	598	Craig	1070237
56823	40290	Troll	8/4/2002	32	SW	104	675	Craig	1070258
78454	40289	Troll	8/4/2002	32	SW		573	Ketchikan	2060303
79599	40290	Troll	8/4/2002	32	SW	103	589	Craig	2070257
56837	40289	Troll	8/5/2002	32	SW	152	552	Craig	2070262
56864	40289	Troll	8/5/2002	32	SW	104	644	Craig	2070267
79917	40290	Troll	8/5/2002	32	SW	152	622	Craig	2070260
79918	40290	Troll	8/5/2002	32	SW	152	688	Craig	2070260
81859	40289	Troll	8/22/2002	34	SW	152	644	Craig	2070358
68236	40289	Troll	8/28/2002	35	SW	104	683	Craig	2070385
68243	40290	Troll	8/28/2002	35	SW	104	634	Craig	2070385
62745	40290	Troll	9/2/2002	36	SW	104	600	Craig	2070401
62792	40290	Troll	9/3/2002	36	SW	104	688	Craig	2070406
68702	40290	Troll	9/3/2002	36	SW	104	644	Craig	2070409
68729	40290	Troll	9/3/2002	36	SW	104	636	Craig	2070409
68404	40290	Troll	9/4/2002	36	SW	104	594	Craig	2070417
68420	40289	Troll	9/4/2002	36	SW	103	646	Craig	2070416
68749	40290	Troll	9/5/2002	36	SW	104	635	Craig	2070424
78113	40290	Troll	7/18/2002	29			545	Ketchikan	2060218
79055	40289	Troll	7/28/2002	31			637	Craig	2070222
506823	40290	Troll	8/6/2002	32			598	Petersburg	2050643
81926	40290	Troll	8/20/2002	34			770	Craig	2070350
68759	40259[1]	Troll	9/4/2002	36			727	Craig	2070418
77939	40290	Troll	9/12/2002	37			664	Ketchikan	2060484
	40290	Troll	8/10/2002	32				B.C. Canada	D618060
	40290	Troll	9/7/2002	36				B.C. Canada	D619080
506852	40289	Purse	8/3/2002	31	NE	109	582	Petersburg	2050622
78673	40290	Purse	7/29/2002	31	SE	101	573	Ketchikan	2060271

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Head number	Tag code	Gear	Recovery date	Stat. week	Quad.	Dist.	Length	Port survey site	Sample number
78569	40289	Purse	8/3/2002	31	SE	102	531	Ketchikan	2060292
77827	40290	Purse	8/24/2002	34	SE	101	508	Ketchikan	2060398
79000	40290	Purse	8/24/2002	34	SE	101	635	Ketchikan	2060419
77688	40290	Purse	8/29/2002	35	SE	101	557	Ketchikan	2060427
77693	40290	Purse	8/29/2002	35	SE	101	493	Ketchikan	2060427
513206	40290	Purse	9/4/2002	36	SE	102	608	Ketchikan	2060453
78185	40290	Purse	8/4/2002	32	SW	104	599	Ketchikan	2060302
78677	40290	Drift	7/30/2002	31	SE	101	614	Ketchikan	2060277
506750	40289	Drift	8/5/2002	32	SE	106	566	Petersburg	2050638
506787	40290	Drift	8/12/2002	33	SE	106	547	Petersburg	2050722
78782	40290	Drift	8/14/2002	33	SE	101	730	Ketchikan	2060353
78980	40290	Drift	8/14/2002	33	SE	106	649	Ketchikan	2060349
77654	40290	Drift	8/21/2002	34	SE	106	615	Ketchikan	2060400
89226	40289	Drift	8/26/2002	35	SE	106	620	Petersburg	2050873
89070	40290	Drift	9/2/2002	36	SE	106	614	Petersburg	2050970
89615	40289	Drift	9/4/2002	36	SE	106	528	Petersburg	2050937
513237	40290	Drift	9/5/2002	36	SE	106	628	Ketchikan	2060456
89454	40290	Drift	9/10/2002	37	SE	106	675	Petersburg	2050991
89470	40290	Drift	9/10/2002	37	SE	106	711	Petersburg	2050991
89644	40289	Drift	9/10/2002	37	SE	106	543	Petersburg	2050990
89752	40289	Drift	9/10/2002	37	SE	106	581	Petersburg	2050990
173651	40290	Drift	9/11/2002	37	SE	101	675	Metlakatla	2090227
173654	40290	Drift	9/11/2002	37	SE	101	738	Metlakatla	2090227
89807	40289	Drift	9/12/2002	37	SE	106	633	Petersburg	2051014
90000	40289	Drift	9/17/2002	38	SE	106	685	Petersburg	2051033
516637	40289	Drift	9/19/2002	38	SE	106	601	Petersburg	2051040
516682	40290	Drift	9/24/2002	39	SE	106	671	Petersburg	2051074
516776	40289	Drift	9/24/2002	39	SE	106	654	Petersburg	2051074
516737	40290	Drift	9/25/2002	39	SE	106	777	Petersburg	2051077
516787	40290	Drift	9/25/2002	39	SE	106	738	Petersburg	2051086
234000	40290	Recreational	8/23/2002	34	NW	113	580	Sitka	2035646
172841	40290	Recreational	8/8/2002	32	SE	101	540	Ketchikan	2065326
172553	40290	Recreational	8/27/2002	35	SE	101	780	Ketchikan	2065348
172632	40289	Recreational	9/1/2002	36	SE	101	730	Ketchikan	2065352
205137	40290	Recreational	9/2/2002	36	SE	101	605	Ketchikan	2065400
172876	40290	Recreational	9/7/2002	36	SE	101	580	Ketchikan	2065384
172643	40290	Recreational	9/8/2002	37	SE	101	690	Ketchikan	2065411
205144	40289	Recreational	9/9/2002	37	SE	101	595	Ketchikan	2065441
172661	40292	Recreational	9/14/2002	37	SE	101	745	Ketchikan	2065428
172675	40289	Recreational	9/28/2002	39	SE	101	650	Ketchikan	2065471
172686	40290	Recreational	9/29/2002	40	SE	101	655	Ketchikan	2065482
172689	40290	Recreational	9/29/2002	40	SE	101	680	Ketchikan	2065485
147527	40289	Escapement	9/6/2002	36	SE	101	555	Eulachon River	2932011
147615	40289	Escapement	9/14/2002	37	SE	101	660	Eulachon River	2932014
61139	40290	Escapement	10/6/2002	41	SE	101	480	Eulachon River	2932016
61140	40290	Escapement	10/7/2002	41	SE	101	680	Eulachon River	2932017
61141	40289	Escapement	10/10/2002	41	SE	101	580	Eulachon River	2932019
61142	40290	Escapement	10/10/2002	41	SE	101	680	Eulachon River	2932019
61145	40290	Escapement	10/17/2002	42	SE	101	510	Eulachon River	2932021
61144	40290	Escapement	10/17/2002	42	SE	101	625	Eulachon River	2932021
147534	40290	Escapement	10/19/2002	42	SE	101	640	Eulachon River	2932022
57927	40290	Escapement	8/5/2002	32	SE	101	490	Unuk River	2930053
57928	40290	Escapement	8/7/2002	32	SE	101	590	Unuk River	2930054
57929	40290	Escapement	8/12/2002	33	SE	101	570	Unuk River	2930057

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Head number	Tag code	Gear	Recovery date	Stat. Week	Quad.	Dist.	Length	Port survey site	Sample number
57931	40289	Escapement	8/15/2002	33	SE	101	635	Unuk River	2930058
57930	40290	Escapement	8/15/2002	33	SE	101	505	Unuk River	2930058
57932	40290	Escapement	8/16/2002	33	SE	101	565	Unuk River	2930059
57935	40290	Escapement	8/17/2002	33	SE	101	510	Unuk River	2930060
57933	40290	Escapement	8/17/2002	33	SE	101	565	Unuk River	2930060
57940	40289	Escapement	8/18/2002	34	SE	101	455	Unuk River	2930061
57936	40289	Escapement	8/18/2002	34	SE	101	520	Unuk River	2930061
57941	40290	Escapement	8/18/2002	34	SE	101	495	Unuk River	2930061
57939	40290	Escapement	8/18/2002	34	SE	101	550	Unuk River	2930061
57937	40290	Escapement	8/18/2002	34	SE	101	625	Unuk River	2930061
57942	40290	Escapement	8/19/2002	34	SE	101	490	Unuk River	2930062
57943	40289	Escapement	8/20/2002	34	SE	101	505	Unuk River	2930063
47945	40289	Escapement	8/20/2002	34	SE	101	540	Unuk River	2930063
57944	40290	Escapement	8/20/2002	34	SE	101	490	Unuk River	2930063
57946	40289	Escapement	9/3/2002	36	SE	101	635	Unuk River	2930067
57949	40289	Escapement	9/4/2002	36	SE	101	525	Unuk River	2930068
57950	40289	Escapement	9/4/2002	36	SE	101	555	Unuk River	2930068
58353	40289	Escapement	9/4/2002	36	SE	101	565	Unuk River	2930068
58354	40290	Escapement	9/4/2002	36	SE	101	630	Unuk River	2930068
58356	40289	Escapement	9/5/2002	36	SE	101	585	Unuk River	2930069
58355	40290	Escapement	9/5/2002	36	SE	101	550	Unuk River	2930069
58357	40290	Escapement	9/5/2002	36	SE	101	560	Unuk River	2930069
58359	40290	Escapement	9/6/2002	36	SE	101	480	Unuk River	2930070
58362	40289	Escapement	9/8/2002	37	SE	101	620	Unuk River	2930072
58361	40290	Escapement	9/8/2002	37	SE	101	580	Unuk River	2930072
58365	40290	Escapement	9/9/2002	37	SE	101	515	Unuk River	2930073
58364	40290	Escapement	9/9/2002	37	SE	101	585	Unuk River	2930073
58363	40290	Escapement	9/9/2002	37	SE	101	630	Unuk River	2930073
58367	40289	Escapement	9/11/2002	37	SE	101	590	Unuk River	2930075
58366	40290	Escapement	9/11/2002	37	SE	101	565	Unuk River	2930075
58370	40289	Escapement	9/12/2002	37	SE	101	560	Unuk River	2930076
58369	40290	Escapement	9/12/2002	37	SE	101	535	Unuk River	2930076
58373	40289	Escapement	9/13/2002	37	SE	101	615	Unuk River	2930077
58371	40290	Escapement	9/13/2002	37	SE	101	640	Unuk River	2930077
58372	40290	Escapement	9/13/2002	37	SE	101	645	Unuk River	2930077
58374	40290	Escapement	9/14/2002	37	SE	101	580	Unuk River	2930078
58375	40290	Escapement	9/14/2002	37	SE	101	640	Unuk River	2930078
58378	40290	Escapement	9/14/2002	37	SE	101	670	Unuk River	2930078
58380	40289	Escapement	9/16/2002	38	SE	101	570	Unuk River	2930079
58379	40290	Escapement	9/16/2002	38	SE	101	650	Unuk River	2930079
58382	40290	Escapement	9/19/2002	38	SE	101	510	Unuk River	2930081
58381	40290	Escapement	9/19/2002	38	SE	101	640	Unuk River	2930081
58383	40290	Escapement	9/20/2002	38	SE	101	590	Unuk River	2930082
58384	40290	Escapement	9/23/2002	39	SE	101	670	Unuk River	2930083
58385	40289	Escapement	9/25/2002	39	SE	101	640	Unuk River	2930085
58386	40290	Escapement	9/25/2002	39	SE	101	570	Unuk River	2930085
58387	40290	Escapement	9/25/2002	39	SE	101	665	Unuk River	2930085
58394	40290	Escapement	9/26/2002	39	SE	101	600	Unuk River	2930086
58391	40290	Escapement	9/26/2002	39	SE	101	560	Unuk River	2930086
58389	40290	Escapement	9/26/2002	39	SE	101	570	Unuk River	2930086
58392	40290	Escapement	9/26/2002	39	SE	101	600	Unuk River	2930086
58390	40290	Escapement	9/26/2002	39	SE	101	620	Unuk River	2930086
58388	40290	Escapement	9/26/2002	39	SE	101	670	Unuk River	2930086
58393	40290	Escapement	9/26/2002	39	SE	101	780	Unuk River	2930086

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Head number	Tag code	Gear	Recovery date	Stat. week	Quad.	Dist.	Length	Port survey site	Sample number
61955	40290	Escapement	11/9/2002	45	SE	101	480	Boundary Creek	2939006
147529	40290	Escapement	9/28/2002	39	SE	101	530	Genes Lake Creek	2937015
147531	40290	Escapement	10/3/2002	40	SE	101	540	Genes Lake Creek	2937017
61143	40289	Escapement	10/16/2002	42	SE	101	540	Kerr Creek	2936004
147528	40290	Escapement	9/27/2002	39	SE	101	725	Lake Creek	2934016
147530	40290	Escapement	9/29/2002	40	SE	101	640	Lake Creek	2934017
147532	40289	Escapement	10/11/2002	41	SE	101	550	Lake Creek	2934022
147533	40290	Escapement	10/12/2002	41	SE	101	615	Lake Creek	2934023
SELECT RECOVERIES									
173594	40289	Unknown	8/21/2002	34	SE	101	662	Metlakatla	2090195
212386	40290	Troll	7/31/2002	31	NW	154		Sitka	2039992
216634	40289	Troll	9/2/2002	36	NW	116		Sitka	2031239
236627	40290	Troll	9/2/2002	36	NW	116		Sitka	2031239
124502	40290	Recreational	8/5/2002	32	SE	101		Ketchikan	2065319

[a] Tag code 40259 from spring 2000, not included in marine harvest or smolt abundance estimations.

Appendix A3.–Fates and locations (km) of coho salmon with radio transmitters as recorded at two remote radio towers, by hand-held receivers, and located during four aerial surveys of the Unuk River, 2002.

Date	Frequency	Radio towers	LOCATION BY TRACKING FLIGHT 6-Sep-02	30-Sep-02	28-Oct-02	Assumed fate
9/5/02	151.023	9/15		not found	not found	Spawned
9/23/02	151.045	10/1		KM8	KM31	Spawned
9/7/02	151.063			E6	not found	Spawned
9/20/02	151.084			G2	not found	Spawned
9/18/02	151.104	10/2, 10/7		E5 (SF)	E5	Spawned
9/3/02	151.134	9/8, 9/26	not found	K2	not found	Spawned
9/10/02	151.144	9/14		KM19	G2	Spawned
9/9/02	151.152			G2		Spawned
8/17/02	151.163	9/5, 9/11	G2	KM2	not found	Spawned
9/13/02	151.173	10/4–10/18		KM13	KM13	Spawned
9/12/02	151.193			E5 (SF)	E5	Spawned
9/23/02	151.214	10/4		KM13	KM11	Spawned
9/24/02	151.233	10/2		KM10	BL2	Spawned
8/18/02	151.245	8/20	CR2	BL2	BL2	Spawned
9/8/02	151.253			CR3	KM35	Spawned
9/7/02	151.275			not found	not found	Lost
8/19/02	151.282		not found	not found	not found	Lost
9/9/02	151.293	9/12, 10/1, 10/12		CR2	not found	Spawned
9/11/02	151.314	9/14–20		K2	KM10	Spawned
8/17/02	151.343		E5	KM19	E5	Spawned
8/19/02	151.354	9/6,30, 10/3,12,17	KM13	K2	K2	Spawned
9/12/02	151.375			KM11	not found	Spawned
9/5/02	151.394	9/11		CR2	not found	Spawned
9/3/02	151.412		KM2	KM29	KM34	Spawned
9/11/02	151.435			BL2	not found	Spawned
9/2/02	151.453	9/7	KM6	not found	not found	Spawned
9/25/02	151.463	9/29		KM14	KM18	Spawned
9/5/02	151.474	9/11		CR3	not found	Spawned
9/3/02	151.492	9/6	L2	CR2	CR2	Spawned
9/12/02	151.553			E5 (SF)	E2	Spawned
9/8/02	151.572			E6	E6	Spawned
8/18/02	151.584	9/4		KM63	KM40	Spawned
8/20/02	151.605	9/9	KM2	CR1	CR2	Spawned
8/21/02	151.614	9/5	K2	KM29	CR2	Spawned
8/20/02	151.624		not found	not found	not found	Lost
9/24/02	151.633	10/2, 10/7		L3	not found	Spawned
8/17/02	151.649	10/11	KM3	KM2	KM2	KM2 Mort
9/25/02	151.654	10/8		E2	KM14	Spawned
9/7/02	151.703			KM2	KM2	KM2 Mort
9/7/02	151.724			KM2	KM2	KM2 Mort
9/18/02	151.743	9/23, 10/11		G2	not found	Spawned
9/12/02	151.763	9/16		KM32	not found	Spawned
9/8/02	151.784	9/18		KM24	KM19	Spawned
9/16/02	151.824	10/3		L5	not found	Spawned
9/19/02	151.863	10/15		KM32	KM11	Spawned
9/5/02	151.883	9/11		BL2	BL2	Spawned
9/9/02	151.923	9/14		KM16	KM14	Spawned
9/16/02	151.943			not found	KM2	KM2 Mort
9/11/02	151.983			E6	E6	Spawned

M = Mainstem Unuk, E = Eulachon River, CR = Cripple Creek, SF = South Fork, L = Lake Creek, G = Genes Lake, BL = Boundary Lake.

Appendix A4.–Sulking time of adult coho salmon tagged at SN1 on the Unuk River, 2002.

					Sulk time		
Spaghetti tag #	Date released	Time released	Date recaptured	Time recaptured	Days	Hours	Minutes
2368	4-Aug	1156	7-Aug	1520	3	3	24
2406	5-Aug	1559	11-Aug	906	5	18	7
2410	5-Aug	1646	8-Aug	1740	3	0	54
2417	7-Aug	1131	8-Sept	1636	1	5	5
2426	7-Aug	1705	7-Aug	1720	0	0	15
2439	11-Aug	820	12-Aug	1453	1	6	33
2466	12-Aug	1452	4-Sept	833	22	17	41
2467	12-Aug	1535	19-Aug	1831	7	2	56
2490	15-Aug	1709	3-Sept	1451	18	21	42
2509	16-Aug	1521	19-Aug	1524	3	0	3
2514	16-Aug	1628	19-Aug	1440	2	22	12
2551	17-Aug	1424	20-Aug	1802	3	3	38
2565	17-Aug	1612	19-Aug	1521	1	23	9
2584	18-Aug	1120	8-Sept	946	20	22	26
2598	18-Aug	1300	18-Aug	1421	0	1	21
2646	18-Aug	1725	3-Sept	1129	15	18	4
2652	18-Aug	1800	4-Sept	1034	16	16	34
2660	18-Aug	1845	4-Sept	1718	16	22	33
2666	18-Aug	1845	3-Sept	1653	15	22	8
2667	18-Aug	1845	3-Sept	1346	15	19	1
2679	19-Aug	1052	19-Aug	1522	0	4	30
2683	19-Aug	1135	3-Sept	1229	15	0	54
2777	20-Aug	1300	20-Aug	1355	0	0	55
2827	21-Aug	1506	4-Sept	1132	13	20	26
2831	30-Aug	1304	5-Sept	1310	6	0	6
2897	3-Sept	1626	7-Sept	1403	3	21	37
2903	3-Sept	1710	4-Sept	1447	0	21	37
2466	4-Sept	833	8-Sept	1804	4	9	31
2939	4-Sept	1148	9-Sept	836	4	20	48
2959	4-Sept	1339	14-Sept	1210	9	2	31
3013	4-Sept	1709	9-Sept	1504	4	21	55
3049	5-Sept	1011	9-Sept	1404	4	3	53
3053	5-Sept	1047	9-Sept	953	3	23	6
3064	5-Sept	1218	7-Sept	1448	2	2	26
3077	5-Sept	1357	19-Sept	814	13	18	17
3162	6-Sept	1622	13-Sept	1435	6	22	13
3198	7-Sept	800	8-Sept	1330	1	5	30
3204	7-Sept	850	7-Sept	1006	0	1	16
3242	7-Sept	1158	11-Sept	1050	3	22	52
3248	7-Sept	1227	7-Sept	1607	0	3	40
3257	7-Sept	1307	13-Sept	1245	5	23	38
3266	7-Sept	1348	7-Sept	1446	0	0	58
3329	8-Sept	1114	13-Sept	1445	5	3	31
3349	8-Sept	1305	13-Sept	1437	5	1	32
3393	8-Sept	1531	13-Sept	1305	4	21	34
3412	8-Sept	1743	23-Sept	1151	14	18	8
3417	9-Sept	738	14-Sept	1220	5	4	42

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					Sulk time		
Spaghetti tag #	Date released	Time released	Date recaptured	Time recaptured	Days	Hours	Minutes
3440	9-Sept	954	9-Sept	1025	0	0	31
3445	9-Sept	1024	9-Sept	1045	0	0	21
3446	9-Sept	1042	16-Sept	855	6	22	13
3456	9-Sept	1140	12-Sept	1141	3	0	1
3479	9-Sept	1458	14-Sept	1337	4	22	39
3557	12-Sept	819	19-Sept	1335	7	5	16
3584	12-Sept	1113	12-Sept	1210	0	0	57
3617	12-Sept	1422	13-Sept	1416	0	23	54
3669	13-Sept	1132	18-Sept	942	4	22	10
3676	13-Sept	1240	13-Sept	1415	0	1	35
3700	13-Sept	1500	16-Sept	1306	2	22	6
3751	14-Sept	1203	14-Sept	1215	0	0	12
3759	14-Sept	1247	16-Sept	1230	1	23	43
3809	16-Sept	1400	20-Sept	1436	4	0	36
3844	19-Sept	1017	23-Sept	1037	4	0	20
3895	20-Sept	1117	23-Sept	952	2	22	35
3958	23-Sept	1435	28-Sept	1641	5	2	6
14004	25-Sept	1014	26-Sept	1603	1	5	49
14021	25-Sept	1115	26-Sept	1620	1	5	5

Average sulking time equals 5 days, 14 hours, and 0 minutes.
Minimum sulking time equals 12 minutes.
Maximum sulking time equals 22 days, 17 hours, and 41 minutes.

Appendix A5.–Estimated age and sex composition of adult coho salmon sampled during a two-event mark-recapture experiment on the Unuk River, 2002.

		AGE		
		1.1	2.1	Total
		AGE COMPOSITION OF ADULT COHO SALMON		
		PANEL A: ALL SAMPLES COMBINED		
Female	n	938	214	1,152
	%	40.3	9.2	49.5
	SE of %	1.0	0.6	1.0%
	Escapement	22,354	5,100	27,454
	SE of Esc.	4,906	1,159	6,013
	Avg. Length	587	614	592
	SE Length	1.99	4.69	1.86
Male	n	962	211	1,173
	%	41.4	9.1	50.5
	SE of %	1.0	0.6	1.0%
	Escapement	22,926	5,029	27,955
	SE of Esc.	5,030	1,143	6,122
	Avg. Length	555	590	562
	SE Length	2.25	5.89	2.16
Total	n	1,900	425	2,325
	%	81.7	18.3	100.0
	SE of %	0.8	0.8	
	Escapement	45,281	10,129	55,409
	SE of Esc.	9,884	2,251	12,084
	Avg. Length	571	602	577
	SE Length	1.55	3.80	1.46
			Unique fish sampled	
		PANEL B: FIRST EVENT-MARKING IN THE LOWER RIVER		
		SN1		
Female	n	627	140	767
	%	40.8	9.1	50.0
	SE of %	1.3	0.7	1.3
	Avg. Length	578	607	583
	SE Length	2.24	5.39	2.11
Male	n	641	127	768
	%	41.8	8.3	50.0
	SE of %	1.3	0.7	1.3
	Avg. Length	551	578	555
	SE Length	2.38	6.75	2.31
Total	n	1,268	267	1,535
	%	82.6	17.4	100.0
	SE of %	1.0	1.0	
	Avg. Length	564	593	569
	SE Length	1.68	4.36	1.60
			Unique fish sampled	
			Spaghetti tags released	

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	PANEL C: SECOND EVENT- SAMPLING FOR MARKS			
	TOTAL			
Female	n	311	74	385
	%	39.4	9.4	48.7
	SE of %	1.7	1.0	1.8
	Avg. Length	605	629	609
	SE Length	3.76	8.78	3.50
Male	n	321	84	405
	%	40.6	10.6	51.3
	SE of %	1.7	1.1	1.8
	Avg. Length	565	609	574
	SE Length	4.73	10.43	4.41
Total	n	632	158	790
	%	80.0	20.0	100.0
	SE of %	1.4	1.4	
	Avg. Length	584	618	591
	SE Length	3.13	6.93	2.90
			Total sampled	
			Spaghetti tags recovered	
	EULACHON RIVER			
Female	n	179	27	206
	%	45.9	6.9	52.8
	SE of %	2.5	1.3	2.5
	Avg. Length	603	594	601
	SE Length	4.45	12.45	4.19
Male	n	163	21	184
	%	41.8	5.4	47.2
	SE of %	2.5	1.1	2.5
	Avg. Length	552	548	552
	SE Length	5.59	18.74	5.38
Total	n	342	48	390
	%	87.7	12.3	100.0
	SE of %	1.7	1.7	
	Avg. Length	579	574	578
	SE Length	3.79	11.17	3.59
			Total sampled	
			Spaghetti tags recovered	

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		LAKE CREEK		
Female	n	34	11	45
	%	29.3	9.5	38.8
	SE of %	4.2	2.7	4.5
	Avg. Length	556	605	568
	SE Length	13.67	27.87	12.63
Male	n	50	21	71
	%	43.1	18.1	61.2
	SE of %	4.6	3.6	4.5
	Avg. Length	536	585	550
	SE Length	11.57	21.86	10.66
Total	n	84	32	116
	%	72.4	27.6	100.0
	SE of %	4.2	4.2	
	Avg. Length	544	592	557
	SE Length	8.85	17.07	8.16

		BOUNDARY CREEK		
Female	n	61	27	88
	%	33.0	14.6	47.6
	SE of %	3.5	2.6	3.7
	Avg. Length	638	685	653
	SE Length	7.70	8.38	6.34
Male	n	69	28	97
	%	37.3	15.1	52.4
	SE of %	3.6	2.6	3.7
	Avg. Length	622	675	637
	SE Length	10.80	12.62	8.82
Total	n	130	55	185
	%	70.3	29.7	100.0
	SE of %	3.4	3.4	
	Avg. Length	629	680	644
	SE Length	6.79	7.59	5.54
			Total sampled	
			Spaghetti tags recovered	

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		GENE'S LAKE CREEK		
Female	n	28	7	35
	%	40.6	10.1	50.7
	SE of %	6.0	3.7	6.1
	Avg. Length	595	601	596
	SE Length	12.67	28.15	11.41
Male	n	28	6	34
	%	40.6	8.7	49.3
	SE of %	6.0	3.4	6.1
	Avg. Length	574	638	585
	SE Length	15.00	18.87	13.38
Total	n	56	13	69
	%	81.2	18.8	100.0
	SE of %	4.7	4.7	
	Avg. Length	585	618	591
	SE Length	9.83	17.57	8.73
			Total sampled	
			Spaghetti tags recovered	
		CRIPPLE CREEK		
Female	n	1	1	2
	%	33.3	33.3	66.7
	SE of %	33.3	33.3	33.3
	Avg. Length	565	540	553
	SE Length			12.50
Male	n		1	1
	%		33.3	33.3
	SE of %		33.3	33.3
	Avg. Length		535	535
	SE Length			
Total	n	1	2	3
	%	33.3	66.7	100.0
	SE of %	33.3	33.3	
	Avg. Length	565	538	547
	SE Length		2.50	9.28
			Total sampled	
			Spaghetti tags recovered	

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		KERR CREEK		
Female	n	8	1	9
	%	29.6	3.7	33.3
	SE of %	9.0	3.7	9.2
	Avg. Length	640	580	633
	SE Length	18.13		17.32
Male	n	11	7	18
	%	40.7	25.9	66.7
	SE of %	9.6	8.6	9.2
	Avg. Length	501	581	532
	SE Length	28.09	34.80	23.19
Total	n	19	8	27
	%	70.4	29.6	100.0
	SE of %	9.0	9.0	
	Avg. Length	560	581	566
	SE Length	23.83	30.14	18.78
			Total sampled	
			Spaghetti tags recovered	

Appendix A6.–Estimated harvests of the Unuk River stock of coho salmon in marine commercial and recreational fisheries by statistical week, 2002. Statistical week estimates for the troll and recreational fisheries were approximated by weighting catch by period or biweek by the number of tags recovered in a statistical week.

Stat	Week	Troll					Gillnet	Seine				Sport			Estimated weekly proportion by gear type					Estimated Cumulative	Est. Cumulative Proportion
Week	Begins	NW	NE	SW	SE	Total	SE	SE	SW	NE	Total	SE	NW	Total	Troll	Gillnet	Seine	Sport	Total	Harvest	of Harvest
27	30-Jun	181				181									0.02			0.00	0.01	181	0.01
28	7-Jul			46		46						126		126	0.01			0.10	0.01	353	0.02
29	14-Jul	91				91									0.01	0.00	0.00	0.00	0.01	444	0.03
30	21-Jul	272	260		80	612									0.08	0.00	0.00	0.00	0.04	1,056	0.07
31	28-Jul	91	174	46	160	471	83	511		237	748				0.06	0.02	0.21	0.00	0.08	2,357	0.15
32	4-Aug	272		324	561	1,157	147		83		83	123		123	0.16	0.04	0.02	0.10	0.10	3,867	0.25
33	11-Aug		94		66	159	193				0				0.02	0.06	0.00	0.00	0.02	4,219	0.27
34	18-Aug	221	187	43	329	780	136	517			517		78	78	0.11	0.04	0.15	0.06	0.10	5,730	0.37
35	25-Aug	442		86	527	1,054	91	1,947			1,947	128		128	0.14	0.03	0.56	0.10	0.21	8,949	0.57
36	1-Sep	662	94	300	263	1,319	443	202			202	300		300	0.18	0.13	0.06	0.23	0.15	11,212	0.72
37	8-Sep	552			263	815	1,718					258		258	0.11	0.50	0.00	0.20	0.18	14,004	0.90
38	15-Sep	221			263	484	229								0.07	0.07	0.00	0.00	0.05	14,717	0.94
39	22-Sep				66	66	411					92		92	0.01	0.12	0.00	0.07	0.04	15,286	0.98
40	29-Sep	110				110						185		185	0.02	0.00		0.14	0.02	15,581	1.00
Total		3,113	808	845	2,578	7,344	3,451	3,177	83	237	3,497	1,211	78	1,289	1.00	1.00	1.00	1.00	1.00		
Estimated mean harvest date =		20-Aug	5-Aug	14-Aug	21-Aug	18-Aug	3-Sep	19-Aug	4-Aug	28-Jul	17-Aug	29-Aug	18-Aug	29-Aug					22-Aug		

Appendix A7.–Estimates of mean harvest dates, harvests, and percentage contributions to fisheries for coho salmon bound for the Unuk River in marine fisheries by statistical week, 1998–2002. Statistical week estimates for the troll and recreational fisheries were approximated by weighting catch by period or biweek by the number of tags recovered in a statistical week.

PANEL A: TROLL[a]						
	Northwest Quadrant					
Statistical week	1998	1999[b]	2000[c]	2001	2002	Average 1998–2002
26						
27				1,668	181	370
28	2,896	1,037	658	1,026		1,123
29	724	1,186		1,411	91	682
30	2,534	1,037	987	1,026	272	1,171
31	2,896	1,186	658	770	91	1,120
32	2,172	1,334	987	257	272	1,004
33	362	1,334	562	187		489
34				469	221	138
35	2,430	2,440	240	281	442	1,166
36	810	861	240	1,031	662	721
37	1,620	861		187	552	644
38	810			281	221	262
39		287	127	94		102
40					110	22
41						
Unuk River stock	17,252	11,563	4,459	8,688	3,113	9,015
Harvest all stocks	1,076,843	1,481,444	813,755	1,260,898	802,569	1,087,102
% Unuk River stock	1.6	0.8	0.5	0.7	0.4	0.8
Mean harvest date	2-Aug	5-Aug	26-Jul	27-Jul	21-Aug	
	Northeast Quadrant					
Statistical week	1998	1999	2000	2001	2002	Average 1998–2002
26						
27				146		29
28		216	426			128
29		108		437		109
30	409	216	426		260	262
31		323		146	174	129
32	819	108		146		214
33	588	323	282	95	94	276
34				95	187	56
35				95		19
36		105			94	40
37						
38						
39						
40						
41						
Unuk River stock	1,816	1,398	1,134	1,160	808	1,263
Harvest all stocks	167,754	306,586	95,421	218,221	184,901	194,577
% Unuk River stock	1.1	0.5	1.2	0.5	0.4	0.6
Mean harvest date	1-Aug	26-Jul	15-Jul	26-Jul	5-Aug	

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Statistical week	Southwest Quadrant 1998	1999	2000	2001	2002	Average 1998–2002
26						
27		96		56		30
28	247	192		338	46	165
29	247	576	243	113		236
30	741	96	243	338		284
31	247	192		282	46	153
32	494	192	365	507	324	377
33	247	96	243	283		174
34			122	340	43	101
35	346			57	86	98
36		94			300	79
37						
38						
39						
40						
41						
Unuk River stock	2,570	1,533	1,217	2,314	845	1,696
Harvest all stocks	208,530	259,947	131,671	235,096	140,121	195,073
% Unuk River stock	1.2	0.6	0.9	1.0	0.6	0.9
Mean harvest date	27-Jul	18-Jul	25-Jul	30-Jul	14-Aug	

Statistical week	Southeast Quadrant 1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28		70	270			68
29		70		71		28
30	713	209		71	80	215
31	178	348	539	71	160	259
32	1,426			214	561	440
33		278	280	223	66	169
34	361		140	298	329	226
35	541	508		149	527	345
36		610	419	149	263	288
37	361	610	280	595	263	422
38	722	610		298	263	379
39					66	13
40		203				41
41						
Unuk River stock	4,303	3,514	1,927	2,139	2,578	2,892
Harvest all stocks	182,092	212,405	83,139	126,249	181,058	156,989
% Unuk River stock	2.4	1.7	2.3	1.7	1.4	1.8
Mean harvest date	14-Aug	23-Aug	6-Aug	25-Aug	21-Aug	

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Statistical week	TROLL QUADRANTS COMBINED 1998	1999	2000	2001	2002	Average 1998–2002
26						
27		96		1,870	181	429
28	3,143	1,514	1,354	1,364	46	1,484
29	971	1,938	243	2,032	91	1,055
30	4,398	1,557	1,657	1,435	612	1,932
31	3,321	2,048	1,198	1,269	471	1,661
32	4,911	1,633	1,352	1,124	1,157	2,035
33	1,197	2,031	1,367	788	159	1,108
34	361		261	1,202	780	521
35	3,317	2,948	240	582	1,054	1,628
36	810	1,670	659	1,180	1,319	1,127
37	1,981	1,471	280	782	815	1,066
38	1,532	610		579	484	641
39		287	127	94	66	115
40		203			110	63
41						
Unuk River stock	25,941	18,008	8,737	14,301	7,344	14,866
Harvest all stocks	1,635,219	2,260,382	1,123,986	1,840,464	1,308,649	1,633,740
% Unuk River stock	1.6	0.8	0.8	0.8	0.6	0.9
Mean harvest date	3-Aug	6-Aug	28-Jul	1-Aug	18-Aug	

PANEL B: DRIFT GILLNET

Statistical week	District 101 [d] 1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29		123				25
30						
31				87	83	34
32						
33					69	14
34	406	195		135		147
35				314		63
36	2,205	317		63		517
37		133		353		97
38	412	186		367		193
39	304	96				80
40		139				28
41						
Unuk River stock	3,327	1,189		1,319	152	1,197
Harvest all stocks	60,265	64,526	18,209	35,504	35,516	42,804
% Unuk River stock	5.5	1.8		3.7	0.4	2.8
Mean harvest date	31-Aug	29-Aug		2-Sep	3-Aug	

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Statistical week	District 101 MIC 1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29						
30						
31						
32						
33				61		12
34						
35	268			86		71
36						
37		53			1,098	230
38						
39		200	144			69
40						
41		62				12
Unuk River stock	268	315	144	147	1,098	394
Harvest all stocks	29,012	42,662	14,173	43,642	55,071	36,912
% Unuk River stock	0.9	0.7	1.0	0.3	2.0	1.1
Mean harvest date	23-Aug	19-Sep	17-Sep	20-Aug	8-Sep	

Statistical week	District 106 1998	1999	2000	2001	2002	Average 1998–2002
26						
27		62				12
28		85				17
29		82		126		42
30						
31	264	199	182	136		156
32	278	73			147	100
33	487	196	515		124	264
34	1,262	198	182	463	136	448
35	549	107	281	208	91	247
36	291	444	1,006		443	437
37	567	817		765	620	554
38	328	954			229	302
39	575	531			411	303
40		180		196		75
41		67				13
Unuk River stock	4,601	3,995	2,166	1,894	2,201	2,971
Harvest all stocks	273,197	203,262	96,207	188,465	226,560	197,538
% Unuk River stock	1.7	2.0	2.3	1.0	1.0	1.5
Mean harvest date	23-Aug	31-Aug	16-Aug	28-Aug	4-Sep	

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Statistical week	DRIFT GILLNET DISTRICTS COMBINED 1998	1999	2000	2001	2002	Average 1998–2002
26						
27		62				12
28		85				17
29		205		126		66
30						
31	264	199	182	223	83	190
32	278	73			147	100
33	487	196	515	61	193	290
34	1,668	393	182	598	136	595
35	817	107	281	608	91	381
36	2,496	761	1,006	63	443	954
37	567	1,003		1,118	1,718	881
38	740	1,140		367	229	495
39	879	827	144		411	452
40		319		196		103
41		129				26
Unuk River stock	8,196	5,499	2,310	3,360	3,451	4,563
Harvest all stocks	362,474	310,450	128,589	267,611	317,147	277,254
% Unuk River stock	2.3	1.8	1.8	1.3	1.1	1.6
Mean harvest date	27-Aug	31-Aug	25-Aug	31-Aug	3-Sep	

PANEL C: PURSE SEINE [e]

Statistical week	District 101 1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29						
30		254	288	301		169
31		153		813	115	216
32						
33		234				47
34		1,153		1,631	517	660
35		477			1,947	485
36						
37						
38						
39						
40						
41						
Unuk River stock		2,271	288	2,745	2,579	1,577
Harvest all stocks	57,558	31,292	17,277	55,405	54,930	43,292
% Unuk River stock		7.3	1.7	5.0	4.7	3.6
Mean harvest date		11-Aug	16-Jul	9-Aug	22-Aug	

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Statistical week	District 102 1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29				5,604		1,121
30						
31					396	79
32				884		177
33						
34						
35						
36					202	40
37						
38			204			41
39						
40						
41						
Unuk River stock			204	6,488	598	1,458
Harvest all stocks	71,394	42,359	29,549	119,407	78,114	68,165
% Unuk River stock			0.7	5.4	0.8	2.1
Mean harvest date			10-Sep	17-Jul	8-Aug	

Statistical week	District 103 1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29						
30						
31						
32						
33						
34				210		42
35				465		93
36						
37						
38						
39						
40						
41						
Unuk River stock				675		135
Harvest all stocks	45,877	17,615	17,219	56,067	50,884	37,532
% Unuk River stock				1.2		0.4
Mean harvest date				23-Aug		

-continued-

	District 104					
Statistical week	1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29	482					96
30			242			48
31	514			144		132
32		301		546	83	186
33	974		493	657		425
34		727				145
35						
36						
37						
38						
39						
40						
41						
Unuk River stock	1,970	1,028	735	1,347	83	1,033
Harvest all stocks	102,671	68,448	72,056	134,203	15,719	78,619
% Unuk River stock	1.9	1.5	1.0	1.0	0.5	1.3
Mean harvest date	29-Jul	10-Aug	30-Jul	7-Aug	4-Aug	

	District 105					
Statistical week	1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29						
30						
31						
32						
33				134		27
34						
35						
36						
37						
38						
39						
40						
41						
Unuk River stock				134		27
Harvest all stocks	2,092	3,211	229	4,671	434	2,127
% Unuk River stock				2.9		1.3
Mean harvest date				9-Aug		

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Statistical week	1998	1999	2000	2001	2002	Average 1998–2002
	District 106					
26						
27						
28						
29						
30						
31						
32	444					89
33						
34			372			74
35		364		261		125
36	872					174
37				113		23
38						
39						
40						
41						
Unuk River stock	1,316	364	372	374		485
Harvest all stocks	18,874	11,483	3,162	35,712	440	13,934
% Unuk River stock	7.0	3.2	11.8	1.0		3.5
Mean harvest date	20-Aug	22-Aug	20-Aug	30-Aug		

Statistical week	1998	1999	2000	2001	2002	Average 1998–2002
	District 107					
26						
27						
28						
29						
30						
31						
32						
33						
34				376		75
35						
36						
37						
38						
39						
40						
41						
Unuk River stock				376		75
Harvest all stocks	3,030	8,968	3,625	20,189	6,175	8,397
% Unuk River stock				1.9		0.9
Mean harvest date				19-Aug		

-continued-

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Statistical week	District 109 1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29						
30						
31					237	47
32		267				53
33	553		346			180
34	761	245				201
35						
36						
37						
38						
39						
40						
41						
Unuk River stock	1,314	512	346		237	482
Harvest all stocks	82,356	104,443	18,083	59,753	104,609	73,849
% Unuk River stock	1.6	0.5	1.9		0.2	0.7
Mean harvest date	13-Aug	7-Aug	6-Aug		28-Jul	

Statistical week	District 112 1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29						
30						
31						
32				45		9
33						
34						
35						
36						
37						
38						
39						
40						
41						
Unuk River stock				45		9
Harvest all stocks	50,361	60,724	28,992	35,270	54,758	46,021
% Unuk River stock				0.1		<0.1%
Mean harvest date				5-Aug		

-continued-

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Statistical week	1998	1999	2000	2001	2002	Average 1998–2002
	PURSE SEINE DISTRICTS COMBINED					
26						
27						
28						
29	482			5,604		1,217
30		254	530	301		217
31	514	153		957	748	474
32	444	568		1,475	83	514
33	1,527	234	839	791		678
34	761	2,125	372	2,217	517	1,198
35		841		726	1,947	703
36	872				202	215
37				113		23
38			204			41
39						
40						
41						
Unuk River stock	4,600	4,175	1,945	12,184	3,497	5,280
Harvest all stocks	434,213	348,543	190,192	520,677	366,063	371,938
% Unuk River stock	1.1	1.2	1.0	2.3	1.0	1.4
Mean harvest date	8-Aug	11-Aug	5-Aug	29-Jul	17-Aug	

PANEL D: RECREATIONAL

Statistical week	1998	1999	2000	2001	2002	Average 1998–2002
	Sitka					
26		150				30
27		150		123		55
28						
29						
30						
31						
32	371	251				124
33	741	125		194		212
34			206	97	78	76
35		127	206			67
36						
37						
38						
39						
40						
41						
Unuk River stock	1,112	802	412	414	78	564
Harvest all stocks	42,524	73,757	38,247	78,278	46,154	55,792
% Unuk River stock	2.6	1.1	1.1	0.5	0.2	1.0
Mean harvest date	6-Aug	23-Jul	16-Aug	1-Aug	18-Aug	

-continued-

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Statistical week	Craig					
	1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28						
29						
30				322		107
31				158		53
32			461			154
33				158		53
34						
35						
36						
37						
38						
39						
40						
41						
Unuk River stock	N/A	N/A	461	638		366
Harvest all stocks	N/A	N/A	34,987	53,994	33,201	40,727
% Unuk River stock			1.3	1.2		0.9
Mean harvest date			30-Jul	28-Jul		

Statistical week	Ketchikan					
	1998	1999	2000	2001	2002	Average 1998–2002
26						
27						
28					126	25
29				75		15
30		130		75		41
31						
32	1,805	80		163	123	434
33				84		17
34	1,334	165		84		317
35		83		251	128	92
36		174		335	300	162
37	1,183	232		415	258	418
38	369	130		124		125
39					92	18
40					185	37
41						
Unuk River stock	4,691	994		1,605	1,211	1,700
Harvest all stocks	24,059	20,719	38,247	26,693	33,889	28,721
% Unuk River stock	19.5	4.8		6.0	3.6	5.9
Mean harvest date	18-Aug	21-Aug		25-Aug	29-Aug	

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	RECREATIONAL LOCATIONS COMBINED					
Statistical week	1998	1999	2000	2001	2002	Average 1998–2002
26		150				30
27		150		123		55
28					126	25
29				75		15
30		130		397		105
31				158		32
32	2,176	331	461	163	123	651
33	741	125		436		260
34	1,334	165	206	181	78	393
35		210	206	251	128	159
36		174		335	300	162
37	1,183	232		415	258	418
38	369	130		124		125
39					92	18
40					185	37
41						
Unuk River stock	5,803	1,796	873	2,657	1,289	2,484
Harvest all stocks	66,583	94,476	111,481	158,965	113,244	108,950
% Unuk River stock	8.7	1.9	0.8	1.7	1.1	2.3
Mean harvest date	15-Aug	8-Aug	7-Aug	15-Aug	29-Aug	

[a] Traditional troll harvest only.

[b] Unuk River harvest estimates for SE troll (weeks 35–40), NW troll (week 32), and SE recreational (weeks 37–38) revised from those previously published (Jones et al. 2001a).

[c] Unuk River harvest estimates for NW troll (weeks 28–32) revised from those previously published (Jones et al., 2001b).

[d] Traditional Tree Point fishery harvest only.

[e] Traditional purse seine harvest only.

APPENDIX B

Appendix B1.–Estimates of smolt abundance for the Unuk River.

Abundance of smolt emigrating in 2001 was estimated with information gathered in that year and from returning adults in 2002. Petersen's model was used as the estimator under the conditions that every smolt (or adult) had an equal chance of being in the mark-recapture experiment and that the population was closed to recruitment. Fidelity of salmon to their natal watershed produces a de facto closure to recruitment from other populations, so long as sampling occurs in river, as is the case in the here. However, every smolt and adult did not have an equal chance of being included in the experiment because groups of smolts were marked and survived at different rates. Evidence for these differences and the means to counteract their effects are provided below.

When a population is divided into two groups labeled (1) and (2), Petersen's model of a mark-recapture experiment can be expressed as:

$$N_1 + N_2 = (N_1\alpha_1 + N_2\alpha_2)\frac{N_1\alpha_1 S_1\beta_1 + N_2\alpha_2 S_2\beta_2 + N_1(1-\alpha_1)S_1\beta_1 + N_2(1-\alpha_2)S_2\beta_2}{N_1\alpha_1 S_1\beta_1 + N_2\alpha_2 S_2\beta_2} \qquad \text{(B.1)}$$

where N is abundance, α is the rate at which members of the group are marked (tagged), S the rate at which members survive to return as adults, and β the rate at which surviving members are captured. If all adults have an equal probability of being captured in the experiment regardless of group membership, and of their having or not having a mark, then $\beta_1 = \beta_2 = \beta$, and the equation above reduces to:

$$N_1 + N_2 = (N_1\alpha_1 + N_2\alpha_2)\frac{N_1\alpha_1 S_1 + N_2\alpha_2 S_2 + N_1(1-\alpha_1)S_1 + N_2(1-\alpha_2)S_2}{N_1\alpha_1 S_1 + N_2\alpha_2 S_2} \qquad \text{(B.2)}$$

Relationships between capture rates and between survival rates by group can be expressed as $\alpha_2 = \alpha_1 A$ and $S_2 = S_1 B$, respectively. Plugging these relationships into the equation immediately above and simplifying produces:

$$N_1 + N_2 = \frac{(N_1 + AN_2)(N_1 + BN_2)}{N_1 + ABN_2} \qquad \text{(B.3)}$$

Note that this result is false only when A ≠ 1 (i.e., $\alpha_1 \neq \alpha_2$) <u>and</u> B ≠ 1 (i.e., $S_1 \neq S_2$) , that is, when groups of smolts are tagged at different rates and survive at different rates.

Evidence shows that larger smolts (group 2) in 2001 survived at better rates ($S_1 < S_2$) than did smaller smolt (group 1). In 2001 we established two groups of tagged smolt based on length: all < 83 mm long and all ≥ 83 mm. We did not tag smolt < 70 mm because experience has shown that many fish of this size hold over an extra year. We tagged 11,960 fish to represent smaller-smolt group and 11,920 to represent the larger-smolt group. A year later we recovered 65 tags from the smaller-smolt group and 160 from the larger in river and from marine fisheries. The rate of return is significantly different ($\chi^2 = 40.05$, df = 1, P < 0.000001) implying that the survival rate for larger smolt was 2.470 (= B) times the rate for smaller smolt.

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Evidence also shows that $\alpha_2 > \alpha_1$, that is, larger fish were marked at a higher rate. The table below contains information on tags recovered during the second sampling event of the experiment (at the setnet site) split into age of the fish tagged:

Set gillnet recoveries	Age 1.1	Age 2.1	Unknown	Total
Smaller smolt (1)	**12 = $R_{1(1.1)}$**	**0 = $R_{1(2.1)}$**	**5**	**17 = R_1**
Larger smolt (2)	**21 = $R_{2(1.1)}$**	**8 = $R_{2(2.1)}$**	**11**	**40 = R_2**
Unknown	**7 = $R_{3(1.1)}$**	**0 = $R_{3(2.1)}$**	**1**	**8 = R_3**
Total	**40**	**8**	**17**	**65**

Of the 1,819 salmon captured at the set gillnet site, age was determined for 1,534 with 82.7% (1,268) being age 1.1 (266 were judged as age 2.1). This relative age composition of adults can be expressed as:

$$0.827 = \frac{N_1S_1 + N_2\theta\ S_2}{N_1S_1 + N_2S_2} = \frac{N_1S_1 + N_2\theta BS_1}{N_1S_1 + N_2BS_1} = \frac{N_1 + N_2\theta B}{N_1 + N_2B}$$

where θ is the fraction of the larger-smolt group composed of fish age 1.1. An estimate of θ can be calculated from statistics in the second row of the table above plus recoveries on the spawning grounds:

Spawning ground recoveries	Age 1.1	Age 2.1	Unknown	Total
Smaller smolt (1)	**5**	**0**	**0**	**5**
Larger smolt (2)	**6 = $r_{2(1.1)}$**	**4 = $r_{2(2.1)}$**	**2**	**12**
Unknown	**0**	**0**	**0**	**0**
Total	**11**	**4**	**2**	**17**

The estimate $\hat{\theta}$ = 0.6923 = (21+6)/(21+6+8+4)]. Remembering that $\hat{B}$ = 2.470, the equation immediately above can be rearranged and simplified to show that $N_2 = 0.52N_1$. Plugging this relationship into $\alpha_2N_2 = 11{,}920$ produces $\alpha_2N_1 = 22{,}799$. Dividing this result by $\alpha_1N_1 = 11{,}960$ produces the relationship $\alpha_2 = \alpha_1(1.91)$ where $\hat{A} = 1.91$. This lower marking rate for the smaller-smolt group is consistent with some, but not necessarily all, young salmon < 70 mm smolting in 2001.

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Fortunately, the same approach to detect problems with different marking and survival rates can be used to adjust Petersen's model to produce a relatively unbiased estimate of smolt abundance. Note that for an estimate using Chapman's modification of Petersen's model, $\hat{N} = (M_1 + M_2 + 1)(C + 1)/(R_1 + R_2 + 1)$ where M is the number marked by group, C the number inspected for marks, and R the number of marks recovered by group. Since $A > 1$ and $S > 1$, $N > \hat{N}$. However, if the smaller-smolt group had had the same marking rate as the larger-smolt group, AM_1 smolt would have been marked and AR_1 would have been recaptured as adults. Plugging these consequences into the model produces a rescaled estimate:

$$\hat{N}^* = \frac{(\hat{A}M_1 + M_2 + 1)(C + 1)}{\hat{A}R_1 + R_2 + 1} \tag{B.4}$$

The expected value of $\hat{N}^*$ is N because in the rescaled situation the two groups have the same effective marking rate.

Unfortunately, values for R must be estimated because not all recaptured adults can be assigned to a smolt group; tags are shed or heads are lost before tags can be retrieved and decoded. Of the 65 adults recaptured at the set gillnet site, 8 could not be assigned to a smolt-group. Of all tags recaptured and recovered from adults caught in fisheries and or sampled in the river, 28.89% [= 65/(65+160) x 100] were in the smaller-smolt group. Applying this fraction to the 8 recaptured fish of unknown heritage apportions these fish into the two smolt groups. The resulting change in the calculation to estimate abundance is

$$\hat{N}^* = \frac{(\hat{A}M_1 + M_2 + 1)(C + 1)}{\hat{A}(R_1 + \hat{\pi}R_3) + R_2 + (1 - \hat{\pi})R_3 + 1} \tag{B.5}$$

where π is the fraction of recaptured fish from the smaller-smolt group recaptured at the setnet site. In this instance

$$\hat{N}^* = \frac{[1.91(11{,}960) + 11{,}920 + 1](1{,}819 + 1)}{1.91[17 + 8(0.2889)] + 40 + (1 - 0.2889)(8) + 1} = 757{,}080$$

where C = 1,819 (the number of adults sampled in the second sampling event in the experiment. Contrast $\hat{N}^*$ to the biased $\hat{N}$ which equals 658,537, some 13% less.

Variance and relative statistical bias in the rescaled estimator were estimated through bootstrapping frequencies of capture histories as suggested in Buckland and Garthwaite (1991). As the mark-recapture experiment was designed, there are 20 capture histories for smolts (see Table B1). The model variable T corresponds to the number of all tags recovered and recaptured from adult salmon by group regardless of the how or where of the recovery or recapture. The model variable U corresponds to the number of unmarked fish by age in the second sampling event (the setnet site). Other model variables are defined in the text above. Values for model variables were used to calculate frequencies (n) for each capture history, then these frequencies were summed to produce a cumulative density function. Each bootstrap sample began by randomly assigning $\hat{N}^*$ virtual fish to produce a series of virtual tallies

$n'(1)$ ... $n'(20)$ according to the density function. In the next step these virtual tallies were used to back-calculate values for virtual model variables R', r', M', T', U', and C'. Virtual model variables were then used to calculate π', θ', p', A', and finally $\hat{N}'$, as per these equations:

$$\pi' = \frac{T_1'}{T_1' + T_2'} \tag{B.6}$$

$$\theta' = \frac{R'_{2(1.1)} + r'_{2(1.1)}}{R'_{2(1.1)} + r'_{2(1.1)} + R'_{2(2.1)} + r'_{2(2.1)}} \tag{B.7}$$

$$p' = \frac{U'_{1.1} + \sum_{i=1}^{3} R'_{i(1.1)}}{U'_{1.1} + U'_{2.1} + \sum_{i=1}^{3}\sum_{j=1}^{2} R_{i(j.1)}} \tag{B.8}$$

$$A' = \frac{(p' - \theta')}{(1 - p')}\frac{T_2'}{T_1'} \tag{B.9}$$

$$\hat{N}' = \frac{(A'M_1' + M_2' + 1)(C' + 1)}{A'(R_1' + \pi' R_3') + R_2' + (1 - \pi')R_3' + 1} \tag{B.10}$$

Then the process was repeated a to create 1000 iterations and 1000 separate estimates $\hat{N}'$. At the end of the iterations, the following statistics were calculated:

$$\overline{N}' = \frac{\sum_{b=1}^{B} N'_{(b)}}{B} \tag{B.11}$$

$$v(\overline{N}') = \frac{\sum_{b=1}^{B} (N'_{(b)} - \overline{N}')^2}{B - 1} \tag{B.12}$$

$$\text{Relative Bias} = \frac{\overline{N}' - \hat{N}*}{\hat{N}*}(100) \tag{B.13}$$

The estimated SE for $\hat{N}^*$ is the square root of $v(\overline{N}')$ or 142,167 making the cv($\hat{N}^*$) = 0.18.8 The statistic $\overline{N}'$ equaled 754,614 for an estimated relative bias of 0.3%. Using the percentile method to estimate a 95% confidence interval about $\hat{N}^*$, the lower bound is 474,579 smolt and the upper 1,038,607 (see Figure B1). Implied in this analysis is the condition that differences in marking and survival rates between groups are "knife-edge." Most likely they are not with changes in rates being smoother with changes in size of smolt. However, the stratification applied here should remove much of the systemic bias in the estimate of abundance (there's demonstrably little statistical bias). What little systemic bias remains is probably negligible when compared to the estimated variance for estimated abundance.

Table B1.–Relationships among history variables, capture histories, and model variables in bootstrap simulations. Note that “captured” and “recaptured” refer to fish caught at the setnet sites. Note that relationships are predicated on the presumption that all adults recaptured from the smaller-smolt group are age 1.1.

History variable	Capture history	Model variables	Values
n(1)	Marked, not seen – Smaller smolt	$M_1 - T_1$	11,960 – 65 = 11,895
n(2)	" " – Larger smolt	$M_2 - T_2$	11,920 – 160 = 11,760
n(3)	Marked, recaptured – Smaller smolt – Age 1.1	$R_{1(1.1)}$	17
n(4)	" " " " – Age 2.1	$R_{1(2.1)}$	0
n(5)	" " " " – Unknown	$R_1 - \sum_{j=1}^{2} R_{1(j.1)}$	17 – (17 + 0) = 0
n(6)	" " – Larger smolt – Age 1.1	$R_{2(1.1)}$	21
n(7)	" " " " – Age 2.1	$R_{2(2.1)}$	8
n(8)	" " " " – Unknown	$R_2 - \sum_{j=1}^{2} R_{2(j.1)}$	40 – (21 + 8) = 11
n(9)	" " – Unknown – Age 1.1	$R_{3(1.1)}$	7
n(10)	" " " – Age 2.1	$R_{3(2.1)}$	0
n(11)	" " " " – Unknown	$R_3 - \sum_{j=1}^{2} R_{3(j.1)}$	8 – (7 + 0) = 1
n(13)	" " – Larger Smolt – Age 1.1	$r_{2(1.1)}$	6
n(14)	" " " " – Age 2.1	$r_{2(2.1)}$	4
n(15)	" " " " – Unknown	$T_2 - R_2 - r_{2(1.1)} - r_{2(2.1)}$	160 – 40 – 6 – 4 = 110
n(16)	Not marked, captured – Age 1.1	$U_{1.1}$	1228
n(18)	" " – Age 2.1	$U_{2.1}$	258
n(19)	" " – Unknown	$C - \sum_{j=1}^{2} U_{j.1} - \sum_{i=1}^{3} \sum_{j=1}^{2} R_{i(j.1)}$	1819 – 1486 – 65 = 268
n(20)	Not marked, not seen	$\hat{N}^* - M_1 - M_2 - C + R_1 + R_2$	

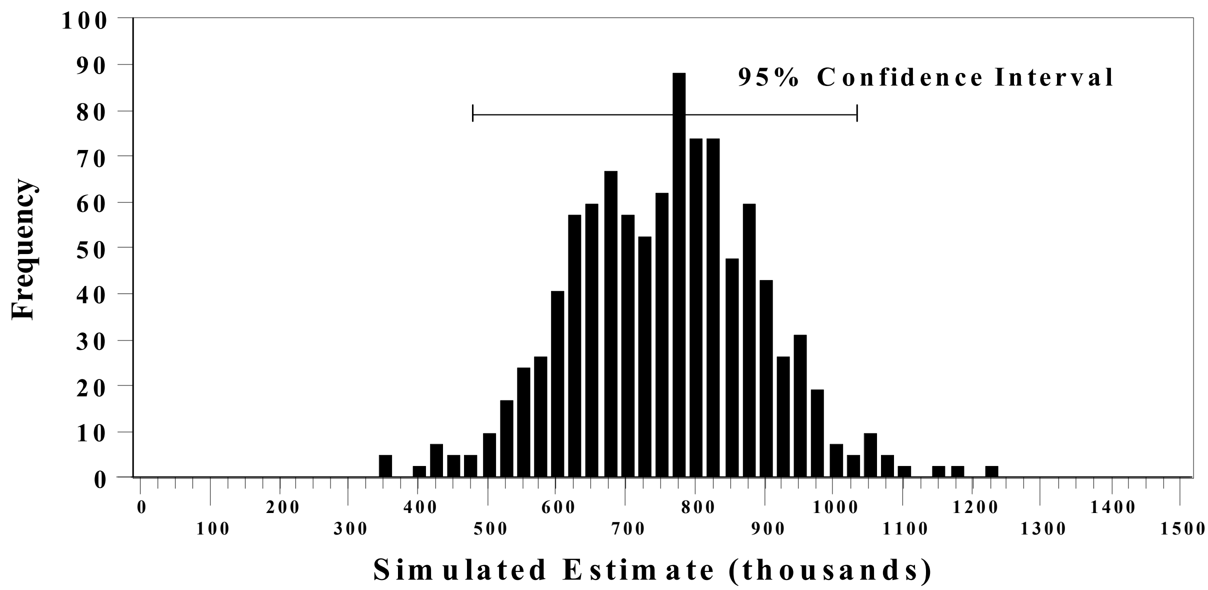

Figure B1.–Frequency of 1000 simulated estimates from bootstrap simulations along with the 90% confidence interval based on the percentile method of calculation.

Appendix B2.–Names of computer files containing data, statistics, and interim calculations concerning stock assessment of the Unuk River stock of coho salmon, 2001–2002.

File name	Description
02UNK43-R.XLS	Spreadsheet containing all the mark-recapture data, various pivot table results, Tables 1–7, Figures 5, 6, 8, and 9, Appendices A2–A6, harvest estimation calculations, abundance estimates, bootstrap results, Kolmogorov-Smirnov (K-S), various χ^2 hypothesis test results, and output from SPAS.EXE for the 2001 Unuk River coho salmon data.
SPAS1.EXE	Stratified Population Analysis (SPAS) program used to perform computer analysis of 2-sample mark-recovery data where each sample is from a geographically or temporally stratified population.
43Spas02.DAT	Data file containing the 2001 Unuk River coho salmon data for use in SPAS.exe.
43KSUNUK02_R.XLS	Kolmogorov-Smirnov (K-S) 2-sample tests, Figures 10 and 11.
43MVHarvest98-02.xls	Spreadsheet containing Appendix A7.